A REPORT ON

AIR QUALITY MONITORING RESULTS IN NEW BRUNSWICK

FOR THE YEAR 2000

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AIR QUALITY MONITORING RESULTS

FOR THE YEAR

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EXECUTIVE SUMMARY

This report summarises air quality monitoring data in New Brunswick for 2000. The report is intended to provide a convenient summary of air quality results for general public information, with emphasis on air quality assessment in relation to existing air quality standards and objectives. Long term trend data are also presented for representative sites. In New Brunswick, air quality standards for carbon monoxide, sulphur dioxide, hydrogen sulphide, nitrogen dioxide and total suspended particulate are specified in the *Air Quality Regulation* of the *Clean Air Act*.

Air quality has been monitored in New Brunswick since the 1960's, when several short-term studies were carried out in Saint John. The emphasis on air monitoring has steadily increased over the years. Air contaminants presently covered by provincial standards were measured at 58 sites in 8 regional monitoring networks across the province during 2000. Acid rain was measured at 13 additional sites. Inhalable particulate matter (PM_{10} and $PM_{2.5}$), ground-level ozone, volatile organic compounds (VOCs), selected semi-volatile organic compounds (PAHs plus dioxins and furans), trace elements in particulate matter and mercury in air and precipitation were also monitored at some locations, although no standards were in effect in New Brunswick for these substances in 2000.

This report presents summary statistics from all monitoring sites in the province, as well as additional statistical data (in chart form) in an Appendix.

The results in this report show that compliance with standards was generally good in 2000, with 100% compliance at many locations, and few sites having compliance rates of less than 95% of the total number of hours measured. Some variation in results is evident between regions and their monitoring networks. This variability is due to many factors including emissions trends, variations in industrial output, changing process or emission control technologies, and the weather conditions experienced in the year.

The average compliance with established air quality standards remained greater than 99% in 2000. There were no exceedances of standards for nitrogen dioxide or carbon monoxide at any of the provincial monitoring sites (nine sites for nitrogen dioxide and three for carbon monoxide). Exceedances for sulphur dioxide, hydrogen sulphide and particulate matter were similar to 1999, whereas ozone exceedances were significantly lower. Additional engineering controls are being implemented by REPAP in the Miramichi region, in an attempt to reduce the number of violations of the hydrogen sulphide standard in that area.

Episode control programs, which are in effect for some major emission sources across New Brunswick, were seen to be effective in reducing the number of occasions on which elevated levels of air pollutants occur. Notable in this regard is the program in place in Saint John, which has enabled almost 100% compliance with a very strict ambient standard for sulphur dioxide. The Department of the Environment and Local

Government continually works with industries to implement the necessary control technologies to ensure compliance with air quality standards.

An examination of air quality trends at sites with long records indicates that since the late 1970s and 1980s, air quality has improved for all pollutants currently being measured, with the possible exception of ground level ozone, for which no clear trend is apparent. Levels of sulphur dioxide, total suspended particulate, and PM_{10} have fallen significantly over the past 15-20 years. Levels of carbon monoxide and nitrogen dioxide have also generally fallen. VOCs have also generally decreased since 1992, and potentially hazardous VOCs remain below guideline values recommended by other agencies.

Monitoring results for polynuclear aromatic hydrocarbons (PAHs) and dioxins and furans, obtained at St Andrews, revealed that levels of these compounds have fallen since 1995, and remain among the lowest observed in Canada.

Data on the trace metal content and general chemistry of particulate matter, sampled at Forest Hills in Saint John since 1992, showed no evident trend for sulphate and nitrate. Concentrations of metals in particulate at this site have fallen over the period of record.

Although acid deposition has generally declined since the early 1990s, acid rain impacts continue to be of concern in the Province, particularly in southwestern districts. Sulphate in precipitation, a key indicator of acid rain, was slightly higher in 2000 than in 1999, although readings remained close to the average for the past 5 years.

Mercury in precipitation has fallen slightly since 1996. There was little evidence of any trend for mercury in ambient air over the same time period.

New Brunswick is continuing its active dialogue, information-sharing, data analysis and policy activities with neighbouring provinces and US states, to make further progress on both ground level ozone and acid rain abatement.

The management of air quality in New Brunswick is based upon the principles set out in the *Clean Air Act*. The Department's goal is full compliance with regulatory standards, and the prevention of degradation of air quality in the province.

Feedback

We are interested in your opinions and feedback on this report. All suggestions will be considered, and if possible, incorporated in future reports. You may contact the Sciences and Reporting Branch at (506) 457-4844, by fax at (506) 453-2265 or e-mail Robert Hughes at robert.hughes@gnb.ca with any comments.

Technical terms

Efforts have been made to keep the number of technical terms used in this report to a minimum. A list of common technical terms are defined or explained in a Glossary of Terms, which begins on page 84.

Report Authorship

Robert Hughes, Sciences and Reporting Branch: Text, data summaries and research.

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1. INTRODUCTION

This report summarises air quality information gathered during 2000 at monitoring locations across New Brunswick. A summary of data from the provincial acid rain network is also included. This report focuses on ambient (i.e. outdoor) air, which provides an indication of environmental quality in terms of air pollution. Some basic information on the emission of air contaminants is contained in section 9.

Air quality has been monitored in New Brunswick since the 1960's, when several short-term studies were carried out. A number of federal and provincial agencies were involved in these co-operative projects, including the N.B. Department of Health. The New Brunswick Department of the Environment was established in 1971. Following this, more routine air quality monitoring began in areas known to be affected by industrial emissions. The accompanying box details a number of significant events in the history of air quality assessment in the Province.

In 1973 the permitting provisions of the first *Air Quality Regulation* took effect, whereby facilities releasing contaminants to the environment could do so only in accordance with terms set out in an Approval to Operate.

AIR QUALITY MILESTONES IN NEW BRUNSWICK
1961-1979

DATE	EVENT
1961	**Smoke and hydrogen sulphide monitoring carried out in Saint John by Transport Canada.**
1964	**Particulate pollution in Saint John studied by the Department of National Health and Welfare.**
1970	**Saint John District Medical Health Officer (DMHO) requested a federal study on air quality in the city.**
1970	**Dustfall and sulphur dioxide assessment began around the Belledune lead-zinc smelter.**
1971	**A five-week study of hydrogen sulphide, particulates and sulphur dioxide carried out in Saint John in response to the request of the DMHO.**
1971	**New Brunswick Department of Fisheries and Environment formed.**
1971	**Environment Canada, the federal environmental protection agency, established. The National Air Pollution Surveillance Network begins operation.**
1971	**New Brunswick *Clean Environment Act* entered force. National Air Quality Objectives proposed.**
1973	**The first provincial *Air Quality Regulation* enacted, including smoke density standards, a permit process for operations emitting air pollution, and limits on the sulphur content of fuel oils.**
1974	**Two-way catalytic converters required for new motor vehicles, to control carbon monoxide and hydrocarbon emissions.**
1975	**Extensive vegetation injury from air pollution seen in Saint John in July. Monitoring networks reviewed and improved.**
1976	**A computerised data collection system set up to gather data from air pollution monitors in Saint John.**
1978	**Air quality monitoring initiated around the Dalhousie thermal generating station.**
1979	**The issuing of a twice-daily air quality index system (Index of the Quality of the Air, or IQUA) began in Saint John.**
1979	**The *Air Quality Regulation* revised, with the inclusion of ambient air quality standards for the first time.**

By the late 1970's, emphasis was also being placed on providing air quality monitoring information to the public. In 1979, an air quality index for public information was introduced in Saint John. The "IQUA" program - (Index of the Quality of the Air) was the first program of its kind to be operated in any Canadian municipality.

2. WHAT'S NEW

New in the provincial air report this year:

- details of continuous fine particulate data ($PM_{2.5}$) for Bathurst (new site, established December 1999) Moncton (established November 1999) and Edmundston (monitor installed June 2000);
- rural ozone data from St Leonard (northwestern NB) and Lower Newcastle (Miramichi area). Both sites began reporting in May 2000;
- total suspended particulate data for two sites operated by Weyerhaeuser in Miramichi;
- volatile organic compound (VOC) measurements made at Champlain Heights School in east Saint John - new site established in October 1999; VOC sampling began July, 2000; sulphur dioxide, October 1999 and nitrogen dioxide, August 2000;
- Details of sampling for trace organic compounds in air at St. Andrews, 1995-2000;
- Details of trace metal content of fine and coarse particulate matter sampled at Forest Hills, Saint John, from 1992-1999.

AIR QUALITY MILESTONES IN NEW BRUNSWICK 1980-2000

DATE	EVENT
1980	The IQUA index reached the very poor range during a serious episode in Saint John in late July and early August, featuring high levels of sulphur dioxide and ozone.
1980	Air quality monitoring started in Edmundston to assess the impact of the Fraser pulp mill.
1987	Three-way catalytic converters required on new motor vehicles, which reduce emissions of nitrogen oxides, as well as carbon monoxide and hydrocarbons.
1987	New Brunswick signs acid rain reduction agreement with Federal Government.
1988	Air quality monitoring established around the Grand Lake thermal generating station.
1989	Monitoring begun in Miramichi around the REPAP paper mill (then the MPPC mill).
1990	Leaded gasoline banned.
1991	Air quality monitoring started around the thermal generating station at Millbank and future site at Belledune.
1993	The provincial *Clean Air Strategy* released, outlining long term plans for air quality protection, enhancement and management.
1993	The smog advisory program (joint program with Environment Canada) began in southern counties of NB, providing public forecasts of high ozone levels.
1995	Air Resource Management Area (ARMA) Committee established in Saint John. The sulphur dioxide standard in Saint John, Kings and Charlotte counties reduced by 50%.
1996	ARMA committees established in Edmundston and Bathurst.
1997	ARMA committees set up in Dalhousie/Campbellton and Miramichi. *Clean Air Act* received government assent.
1997	IQUA issued in Saint John three times daily and available on the Internet. Daily forecasts of ground-level ozone released to the media for Fundy counties of southern New Brunswick (joint program with Environment Canada).
1997	*Clean Air Act* came into force on December 15.
1998	Air quality monitoring site established in Moncton.
1999	IQUA index available hourly via dial-in phone service in Moncton, Saint John and Fredericton. Daily ozone forecasting expanded to central and eastern New Brunswick.
2000	Daily ozone forecasts issued province wide from May to October (joint program with Environment Canada).

3. AIR QUALITY LEGISLATION IN NEW BRUNSWICK

The basic framework for air quality management in New Brunswick is provided by the 1997 *Clean Air Act*. This Act broadly specifies the areas and activities in which the Minister of the Environment and Local Government has authority to make regulations.

In comparison to the *Clean Environment Act,* the *Clean Air Act* is more comprehensive and detailed legislation. It also places major emphasis on providing information to the public and encouraging opportunities for public involvement in decision-making.

Regulations are created under such Acts in accordance with the authority they provide, and set out the detailed requirements which must be followed by individuals or organisations who are subject to the legislation.

Since 1973, the *Air Quality Regulation* has been the Province's principal regulatory tool in this field and, with some recent revisions, it continues to apply under the *Clean Air Act*. It sets out detailed requirements and provisions for a wide range of air quality management issues. Provincial air quality standards have also been contained in this regulation since 1979.

Other regulations which are used to manage air quality cover issues such as Ozone Depleting Substances. As part of the more comprehensive *Clean Air Act*, additional regulations have been prepared, including the *Administrative Penalties Regulation* (which came into force in July 1998) and the *Public Participation Regulation* (which will enter force in April, 2002).

These new regulations are aimed at providing the Province with additional options to promote compliance, and formalising procedures for public review of Certificates of Approval for major emission sources, as well as the process of setting or revising air quality objectives for the Province.

The *Clean Air Act* and its associated regulations are intended for the management of outdoor air quality. Air quality in buildings is regulated by health legislation, including the *Health Act* and the *Occupational Health and Safety Act*.

4. NATIONAL AIR QUALITY STANDARDS AND OBJECTIVES

Air quality management in Canada is primarily a provincial responsibility, although the Federal Government has a key mandate to carry out monitoring and research, as well as manage air issues which have a trans-boundary or international component. An example is the long range movement of air pollutants across provincial or international boundaries, such as those which cause acidic precipitation and ground level ozone.

Canadian air quality objectives are developed by a national committee (the Working Group on Air Quality Objectives and Guidelines) which includes representation from federal and provincial health and environment officials. When finalised through the Working Group process, the resulting "National Ambient Air Quality Objectives" are incorporated in federal legislation under the *Canadian Environmental Protection Act.*

The goal of this process is to ensure some degree of uniformity across the country. Provinces then have the opportunity to incorporate these national objectives in their own environmental legislation. A complete listing of Canada's existing National Air Quality Objectives is contained in Appendix II.

National Objectives cover the major air pollutants of concern. Individual provinces, however, are able to develop additional air quality objectives or guidelines, if deemed necessary for environmental management in their particular jurisdiction. An example of this would be New Brunswick's decision in 1995 to adopt ambient air quality standards for sulphur dioxide (SO_2) in the southern part of the Province (such as the one-hour level of 17 parts per hundred million), which are twice as stringent as the existing National Objectives for this substance.

Recently, a new system for environmental standard-setting has begun, under the guidance of the Canadian Council of Ministers of the Environment, a national body made up of environment Ministers from the federal, provincial, and territorial governments. "Canada Wide Standards" (CWS) are being established for air, water, and possibly soils and sediments. The focus is on setting environmental quality standards which are based on sound science, with the aid of stakeholder public input. Other aspects of the CWS process include a consideration of socio-economic and technical issues as the standards are determined, the incorporation of an implementation plan for each standard, and a commitment for public reporting on the achievement of the standards. More information and updates are available at: http://www.ccme.ca/index.html.

The National Working Group on Air Quality Objectives and Guidelines periodically reviews the latest scientific work dealing with the effects of pollutants on human health, and the environment in general. Based on these reviews, the existing National Air Quality Objectives are revised as required. New objectives may also be proposed.

With the exception of the objective for ground level ozone, New Brunswick has included all National Air Quality Objectives in its *Air Quality Regulation* since 1979. This action has the effect of giving such objectives legal status through the *Air Quality Regulation's* approval process.

In the case of pollutants such as ground level ozone, the management approach in New Brunswick involves reducing the precursor emissions wherever possible, together with concerted regional control efforts, since the majority of ground level ozone measured in New Brunswick originates in the north-eastern United States and, to a lesser extent, southern Ontario and Quebec. This involves federally-led negotiations with States and Provinces which lie upwind from our western border. Precursor emissions are the substances which eventually lead to the formation of the pollutants themselves. For example, ground level ozone results from photo-chemical reactions in the air involving NOx (nitrogen oxides) and VOCs. In this case, NO_x and VOCs are precursors.

On a continental basis, New Brunswick's geographical position is downwind from some of the most heavily populated and industrialised regions of North America. This is why the Province's 1993 Clean Air Strategy has emphasised the need for a special focus on regional air quality management.

5. NEW BRUNSWICK AIR QUALITY STANDARDS

The New Brunswick *Air Quality Regulation* presently defines standards for five pollutants - carbon monoxide, nitrogen dioxide, sulphur dioxide, total suspended particulates and hydrogen sulphide. These numeric standards are indicated in the following table.

NEW BRUNSWICK AIR QUALITY STANDARDS

Pollutant	Averaging period			
	1 hour	8 hour	24 hour	1 year
Carbon monoxide	30 ppm	13 ppm		
Hydrogen Sulphide	11 ppb		3.5 ppb	
Nitrogen dioxide	210 ppb		105 ppb	52 ppb
Sulphur dioxide*	339 ppb (34 pphm)		113 ppb (11 pphm)	23 ppb (2.3 pphm)
Total suspended particulate			120 micrograms/m^3	70 micrograms/m^3

* The standards for sulphur dioxide are 50% lower in Saint John, Charlotte and Kings counties.

These figures are identical to Canada's National Air Quality Objectives, with the exception of the more stringent standards for sulphur dioxide in three southern N.B. counties, noted in the table above.

6. OTHER AMBIENT AIR QUALITY CRITERIA

A. Inhalable Particulate (PM_{10})

There are presently no National Objectives for PM_{10} in Canada. Some existing standards in other areas are shown in the following table. These standards (primarily those from the Greater Vancouver Regional District and the U.S.A.) are currently used as reference points for evaluation of any PM_{10} data gathered in NB. Note: Newfoundland also adopted a 24-hour objective of 25 micrograms per cubic metre for $PM_{2.5}$ in 1997.

PM_{10} Standards in Various Jurisdictions (micrograms per cubic metre)

Jurisdiction (date)	Averaging period	
	24-hour	1 year
GVRD (Vancouver) (1994)	50	30
Newfoundland (1997)	50	-
United States (1987; revised 1997)	150	50
California (1982)	50	30
Australia (1998)	50	-

B. Ground Level Ozone

As with PM_{10}, there is no New Brunswick standard in effect for ground level ozone. For evaluation purposes, the existing National Objectives for ozone are used as a reference and are shown in the following table. Additional information on the National Air Quality Objectives is contained in Appendix II. Note that New Brunswick is participating in the implementation of Canada-wide standards for both $PM_{2.5}$, and ozone. In addition, New Brunswick provided input for the development of an Ozone Annex to the Canada-US Air Quality Agreement, signed in December 2000. The Annex formally recognises the geographic regions in Canada and the US where specific control measures must be applied to reduce ozone formation. It also deals with emission caps or ceilings; technical limits on certain industrial processes; scientific work such as data sharing, mapping and interpretation, and data reporting. The development of this international policy document is seen as potentially useful in the continuing effort to obtain the required emission controls in regions upwind of New Brunswick.

National Ambient Air Quality Objectives for Ozone (ppb)			
Averaging period	Desirable Level	Acceptable Level	Tolerable Level
1 Hour	51	82	153
24 hours	15	25	-
Annual	-	15	-

Note: for an explanation of the different levels, see Appendix II.

7. AIR POLLUTANTS - THEIR SOURCES AND EFFECTS

Basic information is presented in the following sections about the pollutants covered by regulatory ambient standards in New Brunswick. The sources of such pollutants are also discussed, as well as their effects on human health and the environment.

A. Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless and tasteless gas. Major sources include motor vehicles, home heating systems, and refuse burning. Outdoors, CO is generally a problem pollutant only in congested urban centres with high traffic density, especially in winter, as vehicle engines produce more pollution in cold weather. In some traffic conditions, drivers and passengers in vehicles may be exposed to higher levels of CO than pedestrians in city streets. Malfunctioning or badly-vented heating furnaces or stoves may also produce dangerous levels of CO in buildings.

If inhaled, CO quickly enters the blood stream, where it reduces the ability of the blood to deliver oxygen to the organs and tissues of the body. The health impact of CO is most serious for those who suffer from cardiovascular disease, although healthy individuals are also affected at higher concentrations. Exposure to elevated levels is associated with numerous symptoms, including headache, fatigue, nausea, and impairment of vision. Work capacity, learning ability and the ability to perform complex tasks are reduced (Stewart, 1975; USEPA, 1980; Ritchie, 1991; CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1994; 1998).

B. Nitrogen Dioxide

Nitrogen dioxide (NO_2) in high concentrations is a reddish gas with a sharp, pungent smell. It is corrosive and can assist the start and spread of fire. Most NO_2 found in the outdoor environment is not the result of direct emissions. Instead, it forms from nitric oxide (NO), which is emitted by many combustion sources, especially those which operate at high temperatures and pressures.

Motor vehicle engines meet both these characteristics, and are a major source of NO, which reacts quite rapidly with ozone in the air to form NO_2. Collectively, NO and NO_2 are often referred to as nitrogen oxides or NO_x. Thermal electricity generating stations and large heating boilers are other major sources of NO_x.

Nitrogen dioxide can irritate the lungs and lower resistance to respiratory infection. It also has an adverse effect on materials (e.g. corrosion of metals, fading of fabric dyes, degradation of rubber, etc.) and can damage vegetation (CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1987a).

As noted earlier, NO_2 also plays an important role in the formation of ground-level ozone, by reacting with hydrocarbons in the presence of sunlight, and contributes to the formation of acid rain and visibility-reducing haze, or smog.

C. Sulphur Dioxide

Sulphur dioxide (SO_2) is a colourless gas with a characteristic smell, like that of a struck match. When levels reach between 0.3 to 1.0 parts per million (ppm), it is generally detectable as an acidic taste in the air. SO_2 dissolves very readily in water, eventually forming sulphuric acid. SO_2 is one of the most significant pollutants in many industrialised nations: it is often emitted as a result of burning sulphur-containing fuels, and by metal smelters and oil refineries. Emissions of SO_2 from motor vehicles are relatively minor.

Health effects associated with exposure to high concentrations of sulphur dioxide include breathing discomfort, respiratory illness, alterations in the lung's normal defences, and aggravation of existing respiratory and cardiovascular disease. People with asthma, chronic lung or heart disease are the most sensitive to SO_2. Apart from effects on human health, SO_2 can also directly damage the leaves of trees, and agricultural crops. (Environment Canada, 1985; CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1987b). SO_2 also has important indirect impacts by contributing to acid rain, which acidifies lakes and rivers, speeds up the corrosion of masonry and metal objects, and removes essential elements from the soil. Sulphur dioxide also contributes to the formation of acid aerosols (fine acidic particles), which may have detrimental health effects. These small particles cause a visual haze, which affects the enjoyment of scenic vistas and has an effect on the earth's radiation balance.

D. Hydrogen Sulphide

Hydrogen sulphide (H_2S) is a colourless gas with a characteristic smell of rotten eggs. H_2S is flammable and can form an explosive mixture with air or oxygen. Common sources of H_2S include pulp and paper mills, oil refineries, steel processing plants, natural gas plants, and sewage treatment systems. Natural sources include sulphurous hot springs and volcanic vents, swamps and bogs. Naturally-occurring sulphate-reducing bacteria can also produce H_2S in domestic water systems. The processes which produce hydrogen sulphide often generate other sulphur-containing compounds, such as methyl mercaptan and dimethylsulphide. These substances are also highly malodorous, and are often grouped together with hydrogen sulphide and referred to as total reduced sulphur compounds, or TRS.

In the ambient air, the undesirable effects of H_2S are generally felt in terms of a bad odour. The odour threshold for H_2S is generally 1-5 ppb, but can be lower for some individuals. There is some evidence that persistent exposure to unpleasant odours may have an significant effect on community health: review and monitoring of relevant health studies continues.

At higher concentrations (from 2 to approximately 100 ppm) hydrogen sulphide affects the mucous membranes, causing eye and throat irritation. Above this level H_2S becomes life-threatening as the sense of smell is impaired, removing the body's normal warning signal.

High concentrations of hydrogen sulphide can also cause paint discoloration and metal corrosion, and are damaging to plants (Environment Canada, 1984; Masters, 1997). Life-threatening levels, in excess of 300 ppm, can exist in underground sewer pipe systems and occasionally above ground near sewer manholes, in situations where sewer gases are released from underground piping. During drilling for oil and gas, blow-outs can also occur with the release of large quantities of H_2S.

Ambient concentrations in New Brunswick, even in the vicinity of large emission sources, seldom exceed 40 ppb (0.04 ppm).

E. Ground-Level Ozone

Ozone (O_3) is a reactive, unstable form of oxygen. In very high concentrations, it is a bluish gas. The characteristic sharp smell of ozone may be recognised around electrical equipment such as motors or arc welders, where it is formed by the high temperature electric spark. In the concentrations found in outdoor air, even in the most severe pollution episodes, ozone is both colourless and odourless. Ozone is not emitted directly from smokestacks and exhaust pipes, but is formed in the air from other pollutants, most importantly nitrogen oxides (NO_2) and hydrocarbons or VOCs (such as solvent and gasoline vapours).

Vehicle exhaust contains all the necessary compounds to produce ozone, and, as a result, cars and trucks are important contributors to ground level ozone concentrations. Industrial emissions of NO_x and hydrocarbons are also significant precursor emissions for ground level ozone.

Slow-moving air and strong sunshine greatly speed up the formation of ozone. As a result, ground level ozone is not typically a problem pollutant in the cooler months, but is likely to be more significant in hot, hazy summer weather. Such haze may build up over a period of days into a "photochemical smog". However, the yellow or brownish colour of such smog is usually due to nitrogen dioxide and fine chemical particles, not the ground level ozone itself.

Because the formation of ground level ozone depends on weather conditions, the severity of ozone pollution can be very variable from one year to the next. In New

Brunswick, significant ozone episodes occur on average about six times per summer, mainly affecting the southern part of the province. Much of this ozone originates from populated regions of the north-eastern United States, especially the Washington to Boston "corridor".

Ground-level ozone irritates the lungs and can make breathing difficult. Exposure to high concentrations can result in chest tightness, coughing and wheezing. Recent health research suggests there is no threshold concentration below which ozone does not affect human health. Ground level ozone can cause damage to agricultural crops which are ozone-sensitive, such as potatoes and tomatoes. It can also cause noticeable leaf damage in other species. Forest trees and other vegetation may be injured, or growth inhibited. Ozone also weakens rubber, and attacks metals and painted surfaces (Bates, 1980; Multistakeholder NOx/VOC Science Program, 1997c).

Ozone levels are often lower in city centres than in surrounding rural areas. This is because ozone reacts with nitrogen oxides, often found in relatively high concentrations in city cores due to emissions from motor vehicles. This effect is seen in Saint John, although to a lesser extent than in larger cities. A separate network of sites exists to assess rural ozone. The results from that network are discussed later in this report.

F. Total Suspended Particulate (TSP)

Particles in the air (also called "particulates" by air pollution scientists) may either be of natural origin or the result of human activity. Some common natural sources and types of particulates include wind-blown soil dust, forest fires, sea salt, volcanoes, and plants (which produce pollen and spores). Human activities which generate particles include fuel combustion (domestic and industrial) and any other burning (e.g. waste incineration or slash burning); travel on dirt roads, construction work, and mining and quarrying. Dust on road and work sites is often wetted down to control particulate emissions. Other kinds of particles form in the air when gases such as sulphur dioxide (SO_2) and nitrogen oxides (NO_x) react together. These particles are partly responsible for the yellowish "smog" sometimes seen over large cities.

TERMS USED TO DESCRIBE PARTICLES AND HAZE

TSP: Total suspended particulates. A measure of particle concentration determined with a high-volume air sampler, which draws air through a filter over a 24-hour period. Includes particles with a wide range of sizes, up to 25-45 microns in diameter. TSP is normally measured on a nationally-standardised one-in-six day cycle.

PM_{10}: Particulate matter with an effective diameter of 10 microns or less. Also termed "inhalable particulates", as particles of this size are small enough to be inhaled via the mouth and some may enter the lungs.

$PM_{2.5}$: Particulate matter with an effective diameter of 2.5 microns or less, which bypasses filtration in the nose and may be deposited in the lungs. Also referred to as "respirable" particulate.

CoH: Coefficient of Haze. A relative measure of particle concentration determined by drawing air through a paper tape and measuring the change in light transmission of the tape.

Particles, particulates, aerosols: When referring to air quality, these terms are interchangeable, and refer to particles small enough to be transported some distance through the air. Most of these are less than 40 microns in diameter (roughly the size of pollen grains).

Fine particles: Particles with an effective diameter between 0.01 and 2 microns. Most particles forming as a result of industrial processes and combustion (natural or man made) are in this size range. Sometimes loosely used to refer to $PM_{2.5}$. Includes smoke particles.

Coarse particles: Particles with an effective diameter between 2 and 100 microns; includes PM_{10}. Much of the coarse particle load in the atmosphere is of natural (crustal) origin. Also includes pollen and spores.

"Total suspended particulate" (TSP) has been a standard pollution measurement for many years, obtained by drawing a large volume of air through a special filter. This method makes no distinction between natural particles, such as pollen and spores, and particles which are emitted from vehicles or smokestacks.

People with existing breathing complaints such as asthma, bronchitis or emphysema, are liable to be adversely affected by high concentrations of particulates (Wilson and Spengler, 1996; CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1998).

Particulates can also cause corrosion and soiling of metalwork or other materials, damage vegetation, and reduce visibility.

G. Inhalable Particulate (PM_{10})

Particles smaller than 10 microns (a micron is a millionth of a metre, or a thousandth of a millimetre) are called PM_{10}, and are not filtered out of the air by the nose, throat and upper windpipe. As a result, these very small particles can enter the lungs where they may irritate or otherwise have an adverse effect on the delicate membranes and air sacs which absorb oxygen. Other toxic effects may occur, depending on the chemical make up of the fine particles. Because they can enter the lungs, PM_{10} particles are sometimes referred to as 'inhalable' particles, and are measured separately from TSP.

A number of recently published health studies have concluded that lung function, cardio-respiratory mortality, respiratory illness-related hospital admissions, and a variety of other health factors are related to ambient concentrations of PM_{10}. However, which particular aspect of the fine particles is causing these effects has not yet been fully resolved. Particle chemistry, and possibly acidity, may be important. As for ozone, there appears to be no lower concentration threshold below which health effects are not observed. Recent studies also suggest that particles have effects on the immune system (Wilson and Spengler, 1996; Blomberg, 1998).

In Canada, only the Greater Vancouver Regional District (GVRD) and the province of Newfoundland have a standard in place for PM_{10}, although work on developing a national objective is currently under way. In the United States, standards exist both nationally and in California, which has the same standard as the GVRD (see table on page 7).

H. $PM_{2.5}$

Another standard specification for measuring particulates is $PM_{2.5}$, which refers to particles equal to or smaller than 2.5 microns in size. These particles are thought to be of special significance in terms of health impacts, as they have a higher chance of entering and remaining in the lungs if inhaled, compared to PM_{10} or larger particles. They are sometimes referred to as 'respirable particles'.

New particle monitoring technologies have been introduced in recent years which allow the continuous measurement of PM_{10} or $PM_{2.5}$. An example is the TEOM monitor. These units provide continuous, unattended recording and electronic logging and reporting functions. These units are now installed and operating in Saint John, Fredericton, Bathurst, Moncton, and St. Andrews. In June 2000 an additional monitor began operation in Edmundston, maintained by Fraser Paper Inc.

I. Volatile Organic Compounds

VOCs are carbon-containing substances which are present in the air in gas form, usually at low concentrations (in the parts per billion range). Used in the context of air quality, VOCs are substances which often evaporate readily.

Thousands of different VOCs exist in the air. However, many VOCs are of natural origin, and in terms of environmental protection, the VOCs which cause some kind of problem are most important. Everyday examples of VOCs which may be a concern in the environment include gasoline and organic solvents. Other products such as paint, adhesives, and a variety of other household goods may contain solvents which evaporate and contribute to the VOC content of the air. VOCs are also emitted by a wide range of industrial sources, as well as by motor vehicles. Vehicles emit VOCs in their exhaust, and from fuel tanks. Modern vehicles have systems in place to minimize such emissions, but overall, transport-related emissions are still substantial. A large number of VOCs can be emitted by industrial processes (for example by the petrochemicals or plastics industries).

Some VOCs may be potentially toxic to humans, animals or vegetation (e.g. benzene, 1,3 butadiene, ethylene) or are of concern because they can react in the air to form other harmful substances. For example, ethylene and propylene (and many other VOCs) may take part in reactions which lead to the formation of ozone-containing smog. Some VOCs may contribute to undesirable odours, such as various petroleum hydrocarbons.

The VOC sampling program in New Brunswick concentrates on about 150 compounds which are of special interest, including known and suspected carcinogens such as benzene and 1,3 butadiene, and photochemically active VOCs which contribute to smog formation.

8. MONITORING NETWORKS

Compliance with air quality objectives or regulatory standards is determined by monitoring. Because exposure to many air pollutants can occur at any time, most are monitored continuously, although particulates have been an exception. However, new technology now allows continuous measurement. As a result, continuous particulate measurements are gradually becoming more widespread and available.

Monitoring locations are selected so that they will provide information which is representative of the surrounding area. In cases where there is a known pollutant source, monitors are often distributed around it in locations where the impact is expected to be greatest. Such locations are typically selected based on the results of computer dispersion models. These are computer programs which simulate the behaviour of plumes, or discharge streams of gases as they are released from smokestacks. Such models take into account the complete variety of weather conditions which may be experienced in the area where the stack is located, as well as the nature of the local landscape.

In New Brunswick, large industrial emission sources, such as electricity generating stations or pulp mills, are legally required by NBDELG to carry out ambient air quality monitoring as prescribed in their Approvals to Operate. Such Approval conditions also detail the required equipment specifications, locations and reporting frequency. In such cases, the monitoring equipment and maintenance procedures are checked periodically by NBDELG staff or independent auditors, to ensure the required standards for operation and technical accuracy are being met.

In the case of air pollutants which are transported long distances, and which may be found in rural, as well as urban areas, NBDELG establishes and operates its own monitoring sites. The Department also maintains sites in areas where there are multiple large industrial emission sources, such as Greater Saint John. In addition to 13 provincial sites, there is one federally-operated acid rain monitoring site in New Brunswick (at Harcourt, in eastern New Brunswick). Federal support is also provided for the operation of several other air quality monitoring sites across the province (through the National Air Pollution Surveillance program).

The location of air quality monitoring sites and the main regional and local networks are shown on the following map (Figure 1). More detail on the exact location of each site is provided in the following sections.

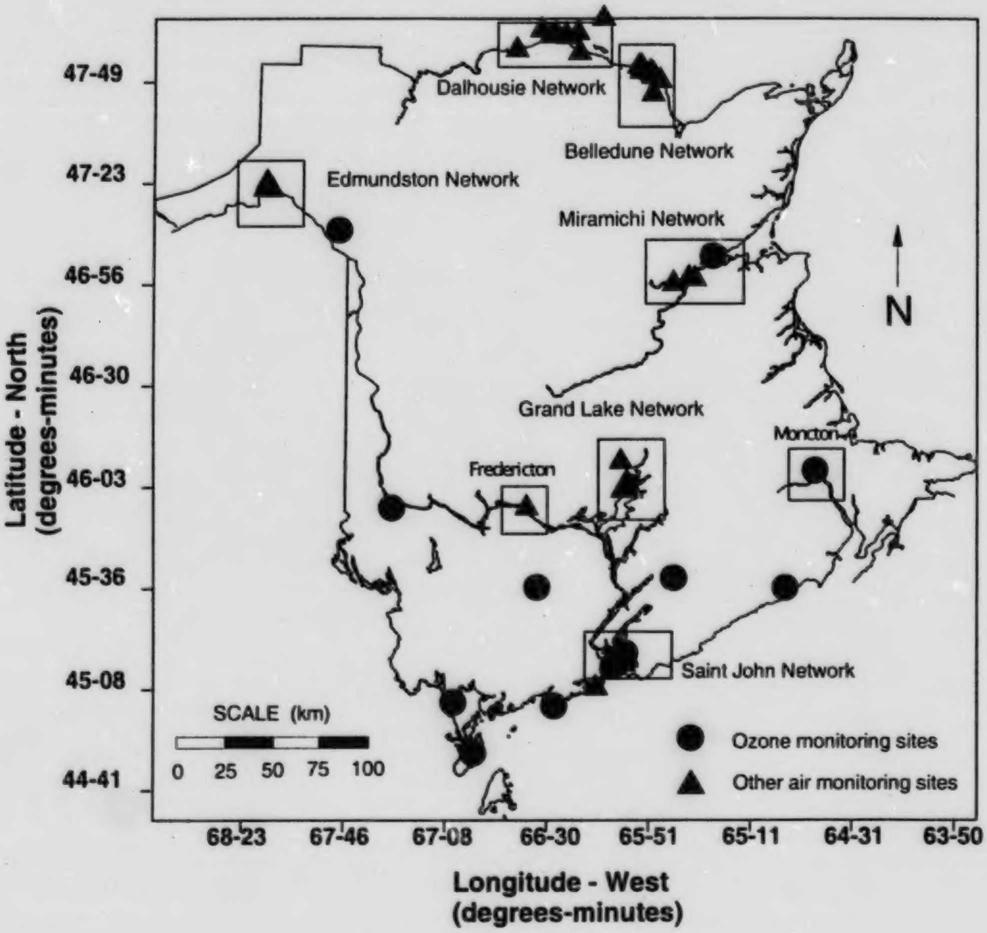

Dalhousie Network
Belledune Network
Edmundston Network
Miramichi Network
Grand Lake Network
Fredericton
Moncton
Saint John Network
N
SCALE (km)
0 25 50 75 100
● Ozone monitoring sites
▲ Other air monitoring sites
Latitude - North (degrees-minutes)
47-49
47-23
46-56
46-30
46-03
45-36
45-08
44-41
68-23
67-46
67-08
66-30
65-51
65-11
64-31
63-50
Longitude - West (degrees-minutes)

Figure 1. Locations of air quality monitoring sites in New Brunswick.

The major industry or urban networks are identified. Filled circles on the map indicate rural ozone sites. The remainder indicate ambient monitoring locations for other substances including sulphur dioxide, nitrogen dioxide and particulates.

9. EMISSIONS OF AIR POLLUTANTS

A summary of the principal air pollutants and their source categories is provided in this section. These figures are based upon routine reports supplied to NBDELG by industries, as well as upon estimates calculated from engineering data and published emission factors.

2000 EMISSIONS - NEW BRUNSWICK

Source Category	Emissions in tonnes per year				
Industrial Sources	Particulate matter	SOx	NOx	CO	VOC
Electric power generation	1266	96976	25765	1579	241
Other commercial fuel combustion	136	484	108	39	10
Pulp mills	1974	9331	2449	2277	741
Other wood industry	511	796	263	791	80
Petroleum refining	256	5936	4259	1293	159
Other chemical industries	33	1	61	6	2
Mining and smelting	216	13062	616	44	6
Transportation	2 268	3 590	37 111	207 354	22 846
TOTAL	6660	130176	70632	213383	24085

Notes: SOx = SO_2 plus SO_3; NOx = NO plus NO_2. Transportation figures are estimates for 1995, source: Environment Canada. VOC = volatile organic compound.

The results are divided into two main categories: industrial sources, and transportation. Industrial sources include major installations such as power generating stations, oil refineries, pulp mills and metal smelters. In such situations, air pollution is typically emitted from a small number of chimney stacks at relatively high rates. In contrast, the transportation category includes domestic and heavy-duty vehicles, plus air, marine and rail emissions. In this category, emissions are usually released at lower rates, spread out over a large area.

In addition to these categories, there are also significant emissions from other sources such as construction, domestic wood burning, and emissions from open sources such as forest fires and dust from roads. **Note that estimates for these categories are not included in the totals given in the table**. Accordingly, the totals here may differ from those quoted elsewhere. The emissions data given here are not intended to be comprehensive. Data are presented for selected sectors to provide a basic understanding of emissions in the major industrial categories, plus transportation. Work is ongoing to improve the accuracy of emissions estimates from all sources. Details of this work can be found on the internet at: http://www.ec.gc.ca/pdb/ape/cape_home_e.cfm.

In 2000, industrial emissions of sulphur oxides (SOx) rose by about 10% from 1999, due to an increase in utility sector emissions. Nitrogen oxide emissions rose about 7%, Emissions of particulates were down 6%, and VOCs were essentially unchanged. CO emissions were also little changed from 1999.

Information to enable detailed, up to date interprovincial comparisons of air pollutant emissions is not available. Some information may be obtained from the web site mentioned in the previous paragraph. In general, New Brunswick emissions are approximately 3%-5% of national totals for most substances. Additional information on air pollutant emissions in New Brunswick may be found in other reports (e.g. Delauriers, 1995; Environment Canada, 1998; Jaques, 1997) or by contacting DELG using the contact details provided on page iii.

10. AIR QUALITY MONITORING RESULTS FOR 2000

This report contains information for 2000. Results are presented for each monitoring network in the Province. The locations of the monitoring sites are shown on regional scale maps. The numeric results are shown in tables, and further details in chart form appear in Appendix III.

Explanatory notes are provided on each network, and a discussion of the results for each network is included.

A. SAINT JOHN

The Saint John area has the longest history of air quality monitoring in New Brunswick, beginning in 1961 (see boxes on pages 1-2). Since that time, air quality has been monitored at more than 30 different locations in the city and surrounding area. Air quality monitoring sites which are presently active (a total of 12 separate locations) are shown on the following map (Figure 2).

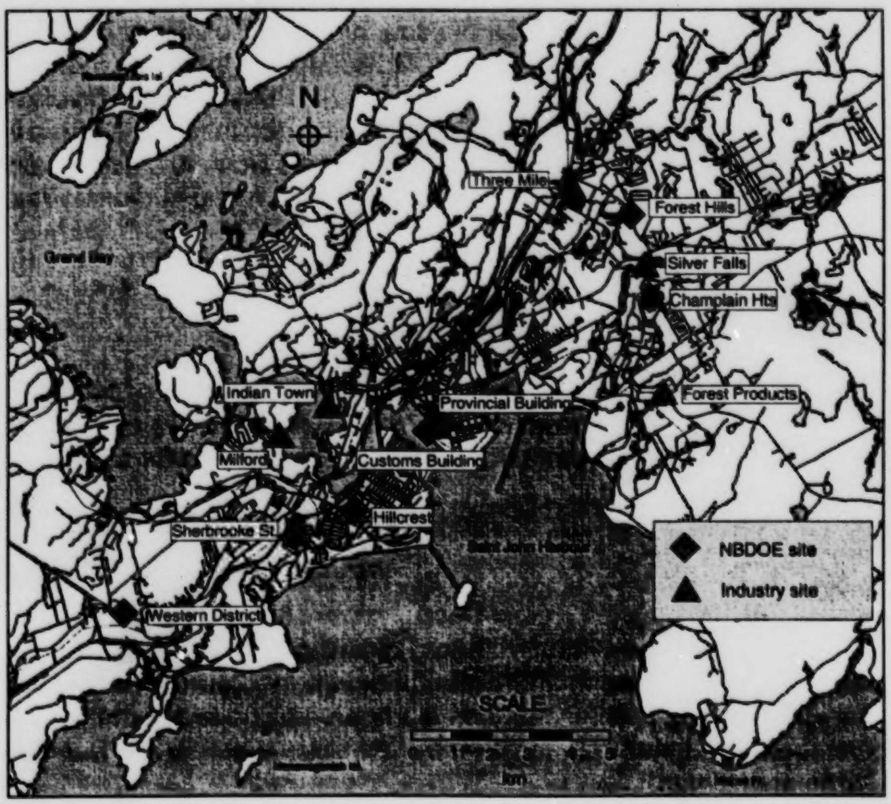

N
Grand Bay
Three Mile
Forest Hills
Silver Falls
Champlain Hts
Indian Town
Provincial Building
Forest Products
Milford
Customs Building
Sherbrooke St.
Hillcrest
Saint John Harbour
Western District
NBDOE site
Industry site
SCALE
km

Figure 2. Air quality monitoring sites in Saint John, New Brunswick.

Most of these sites are electronically linked to a central computer at the NBDELG regional office in Saint John. This system communicates with the monitors a minimum of once each hour and obtains the latest readings. These are then added to the existing data archive and are used to prepare IQUA public information messages, as well as to determine the nature of any abatement actions required by industries if concentrations rise above pre-determined trigger points. Such episode control systems are specified in various Approvals to Operate issued to major emission sources by the Department.

On the City's west side, three monitoring sites for hydrogen sulphide are operated by Irving Pulp and Paper Ltd. NBDELG also operates a site at the Hillcrest Baptist Church off Lancaster Avenue, at which sulphur dioxide, hydrogen sulphide and PM_{10} are monitored, and another site on Manawagonish Road, for PM_{10} only. In east Saint John, three sites for sulphur dioxide are operated by Irving Oil Ltd, as required by the company's operating approval, and results are sent electronically to the Department's data system.

NBDELG also maintains sites at Forest Hills and Champlain Heights in the eastern suburbs, and at the Customs and Provincial buildings in the downtown area. The Customs site has monitors for ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and coefficient of haze (a measure of particulate). At Forest Hills there are monitors for ozone, sulphur dioxide, nitrogen oxides, coefficient of haze, PM_{10}, $PM_{2.5}$ and volatile organic compounds. The Champlain Heights site was relocated in fall 1999 from a private residence on Muriel Avenue to the Champlain Heights School, a distance of about 300 m. During 2000 the site measured sulphur dioxide, nitrogen dioxide (starting in August) and $PM_{2.5}$ (from October).

A.1 Carbon Monoxide

This pollutant is monitored at the Customs Building site to provide data representative of the city centre. Peak hourly values in every month were well below the applicable standard of 30 ppm in 2000. There were also no exceedances of the 8-hour standard of 13 ppm.

A.2 Nitrogen Dioxide

There were no exceedances of the 1-hour standard of 210 ppb at either the Forest Hills or Customs Building monitoring sites in 2000. Neither were the 24-hour standard (105 ppb) or the annual standard (52 ppb) exceeded. Nitrogen dioxide levels at the Customs site tended to be somewhat higher than those at Forest Hills, although still well within the applicable standards at all times.

A.3 Sulphur Dioxide

Some exceedances of the 1-hour and 24-hour standards occurred during 2000, as shown in the following table. There were no exceedances of the annual standard at any site. Compliance with sulphur dioxide standards during 2000, expressed as a percentage of all hours, ranged from 99.95% to 99.99% for the 1-hour standard, and equalled 99.60% for the 24-hour standard.

Exceedances of the 1-hour sulphur dioxide standard in 2000
Saint John (number of hours)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Forest Hills	0	0	0	0	0	0	0	0	0	1	0	0	1
Champlain Hts	3	0	0	1	0	0	0	0	0	0	0	0	4
Hillcrest	0	0	0	0	0	0	0	0	2	0	0	0	2
Customs	0	0	0	0	0	0	0	2	1	0	0	0	3
Three Mile	0	0	0	0	0	0	0	0	0	0	0		0
Forest Products	0	0	0	0	0	1	0	0	0	0	0	0	1
Silver Falls	0	0	0	0	0	0	0	0	0	3	0	0	3
Total	3	0	0	1	0	1	0	2	3	4	0	0	14

The 1 hour standard is 17 pphm, which is equivalent to 170 ppb.

Exceedances of the 24-hour sulphur dioxide standard in 2000
Saint John (number of hours)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Forest Hills	0	0	0	0	0	0	0	0	0	0	0	0	0
Champlain Hts	15	13	0	0	0	0	0	0	0	7	0	0	35
Hillcrest	0	0	0	0	0	0	0	0	0	0	0	0	0
Customs	0	0	0	0	0	0	0	0	0	0	0	0	0
Three Mile	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest Products	0	0	0	0	0	0	0	0	0	0	0	0	0
Silver Falls	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	15	13	0	0	0	0	0	0	0	7	0	0	35

The 24-hour standard is 6 pphm, which is equivalent to 60 ppb.

A.3.1 SULPHUR DIOXIDE EPISODE CONTROL

An episode control program is in place to prevent ambient sulphur dioxide reaching undesirably high levels in Saint John. Control actions are initiated by major industries in the city in response to measurements made at the fixed monitoring sites.

As noted earlier, these control actions are made mandatory by being incorporated into the relevant Approvals to Operate issued by NBDELG. The episode control plans themselves are subject to continual review. NBDELG meets regularly (at least 6 to 8 times per year) with staff of the major industries in the city to review compliance in respect of sulphur dioxide.

All exceedance events are examined in detail and any shortfalls in the nature and extent of response action are addressed. NBDELG staff sometimes request emission control actions separate from or in addition to those specified in the response plans. Such action may be warranted due to unusual conditions, such as poor dispersion, or during periods when smog advisories are in effect.

Some of the ways in which industries respond to rising levels of sulphur dioxide include switching to lower or near-zero sulphur fuels, and reducing production rates or electricity generating rate. Response action is begun when monitored concentrations reach 80 parts per billion, approximately half the 1-hour standard of 170 parts per billion.

Tables of Exceedances - What they Mean

The numbers in the tables of exceedances show the number of occasions when readings were above the standard. For example, the one hour standard for sulphur dioxide in Saint John is 170 ppb. Any hourly period when the measured value was higher than 170 ppb counts as one exceedance of that hourly standard. A 31-day month has 31 x 24 = 744 hours, so the maximum possible number of hourly exceedances for the month would be 744. If that happened, compliance would be 0%. Conversely, with no exceedances, compliance would be 100%.

Where 24-hour standards exist (as for SO_2 and H_2S), compliance is calculated using a running 24 hour average. In other words, not just individual 24 hour calendar days are considered, but every possible 24 hour period in each month, e.g. the 24 hours ending at 10 am on the 5th, the 24 hour period ending at 11 on the 5th, and so on for the whole period in question. Each hour, the 24 hour average is recalculated.

Any hour that the calculation is made and the result is over the 24-hour standard, counts as an exceedance. There could be up to 744 exceedances in a 31-day month. Because a 24-hour average tends to rise and fall gradually, compared to an hourly reading, the total number of 24-hour exceedances is almost always greater than the number of 1-hour exceedances.

A.4 Ground Level Ozone

Ozone was monitored at three sites in the city during 2000: Forest Hills, the Customs Building and in west Saint John at Hillcrest Church. During 2000 there were no exceedances of the 1-hour National Ambient Air Quality Objective for ozone of 82 ppb in the Saint John Network. For information purposes, statistics were also calculated in reference to the new Canada-Wide Standard (CWS) for ozone, which is based on an 8-hour averaging period and is set at 65 parts per billion. There were a total of 13 hours in excess of this value at the Hillcrest site in West Saint John, recorded in May, June and August. New Brunswick (and other provincial governments) have committed to be in compliance with the new CWS for ozone by 2010. In the interim, CWS compliance statistics will be calculated and presented for general assessment purposes.

Further details on ground level ozone follow in section 11, where complete results for all ozone monitoring sites are summarised.

Ozone is an air pollutant which can travel long distances, especially when winds carry the ozone over water (an example is transport from the Boston area to New Brunswick over the Gulf of Maine and Bay of Fundy). Years of monitoring, modelling and trajectory analysis have shown that the vast majority of ground level ozone observed in New Brunswick originates in the north-eastern United States. As part of the new CWS process, emission reductions will be pursued in this source area. Additionally, emission control plans are being prepared to address the ground level ozone issue within New Brunswick and other provinces.

A.5 Particulate matter

A.5.1 PM$_{10}$ HIGH VOLUME SAMPLER

NBDELG operates high volume samplers at four sites in Saint John (Forest Hills, Provincial Building, Hillcrest and Western District Police) which are specially modified to provide data on PM$_{10}$. As noted earlier, there is no Canadian National Objective presently in place for PM$_{10}$, and no provincial standard in New Brunswick. For evaluation purposes, reference is made to the standards in place in Greater Vancouver, the United States, and the State of California (page 7).

The California/GVRD 24-hour standard of 50 micrograms per cubic metre was exceeded twice at the Hillcrest site, twice at the Provincial Building, and once at Forest Hills. There were no exceedances at the Western District Police site during 2000. This represented an improvement in comparison with 1999, which saw relatively high particulate readings.

A.5.2. PM_{10} (TEOM)

PM_{10} was measured during 2000 at Forest Hills using a continuously recording TEOM instrument. Continuous recording provides complete coverage for all hours in the year, as opposed to the 1 in 6 day schedule used nationally for high volume samples.

The 2000 results comprised over 8,500 hours, or more than 97% of the year. Hourly peak values were typically around 80-90 micrograms per cubic metre during most months. Some jurisdictions have a standard of 50 micrograms per cubic metre for PM_{10}, averaged over 24 hours. This value was not exceeded at this site in 2000.

A.5.3 $PM_{2.5}$ (TEOM)

A TEOM device measuring $PM_{2.5}$ was operated at Forest Hills in 2000. Valid data were logged for over 91% of the total hours of the year. There were a few hourly peaks close to 50 micrograms per cubic metre, and one event in January when concentrations exceeded 200 micrograms per cubic metre for two hours. The Canada-Wide Standard for $PM_{2.5}$ is 30 micrograms per cubic metre as a 24-hour average, itself averaged over 3 years (see box). As such it is only possible to determine compliance after a minimum of 3 years of data. In 2000, there were 23 hours exceeding the 24-hour average of 30 micrograms per cubic metre. The 98th percentile reading for the year was 19.8 micrograms per cubic metre.

New Canada-Wide Standard for $PM_{2.5}$: Determining Compliance

Determining compliance with the Canada Wide Standard for $PM_{2.5}$ requires a number of calculations. From all the daily 24-hour averages for the year, the value is computed which is greater than 98% of all the readings. In other words, only 2% of the readings exceeded this value during the year. This is the 98th percentile value. A site is considered in compliance if the average of the 98th percentile values over three consecutive years is below 30 micrograms per cubic metre.

A.5.4 DICHOTOMOUS SAMPLER DATA

Since 1992 an additional sampling program for fine ($PM_{2.5}$) and coarse (PM_{10}) particulate matter has been operated at the Forest Hills site, using a dichotomous sampler. This device collects the particulate matter in each size range on two separate filters (one for $PM_{2.5}$ and one for PM_{10}). The unit runs for 24 hours each time a sample is collected. Sampling frequency has varied over the period of record, with daily sampling May-September in 1992, 1993, and 1994; daily sampling all year in 1995 and 1996, and one day in six sampling from 1997-1999. No data were available for 2000, due to equipment problems. A new sampler is scheduled for installation in 2001.

This sampling program is carried out with the support of the Environmental Technology Centre Laboratory of Environment Canada in Ottawa.

For each sample, ambient air PM_{10} and $PM_{2.5}$ concentrations are calculated. Approximately one sample in six is selected for further chemical analysis. The full analysis includes sulphate (SO_4), nitrate (NO_3), sulphur, chlorine, phosphorus, silicon, and approximately 50 trace metals. Results for some of the substances of greatest interest are summarised here.

Figures 3 and 4 show results for PM_{10} and $PM_{2.5}$ mass, providing integrated information on particulate matter in these size ranges. Detail is especially great for the period 1993-1996, when a large number of daily samples were collected.

A decreasing trend is apparent for both PM_{10} and $PM_{2.5}$ over the period of record. This is consistent with results obtained for particulate matter using other sampling methods, such as TSP and PM_{10} using high-volume samplers. An annual cycle is apparent for both particle size fractions, with higher values observed in the summer. The reasons for this include more rapid chemical reactions in the atmosphere in summer, which lead to the formation of particulate matter, and the fact that at this time of year, winds blow frequently from more polluted source regions.

Figures 5 and 6 show results for sulphate (SO_4) and nitrate (NO_3) as determined using the dichotomous sampler. In each case the result is the concentration derived from the PM_{10} and $PM_{2.5}$ fractions added together. For sulphate, the majority (80-90%) of the mass is present in the fine ($PM_{2.5}$) fraction. Nitrate is not as well- characterised using the dichotomous sampler, due to losses of volatile nitrate constituents such as ammonium nitrate from the filters while in the sampler (Dann, 1994).

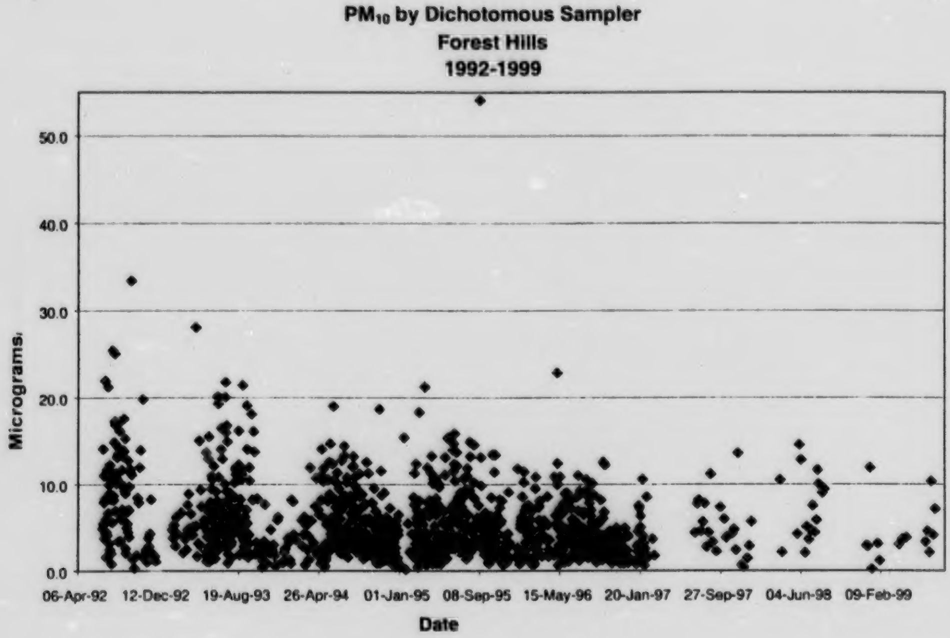


Figure 3. PM$_{10}$ measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

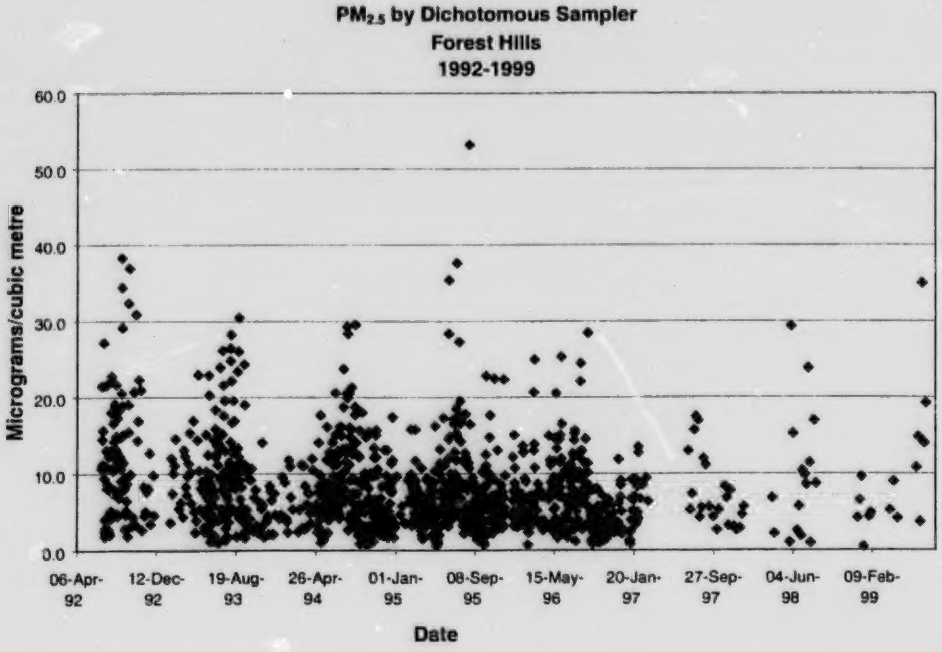


Figure 4. PM$_{2.5}$ measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

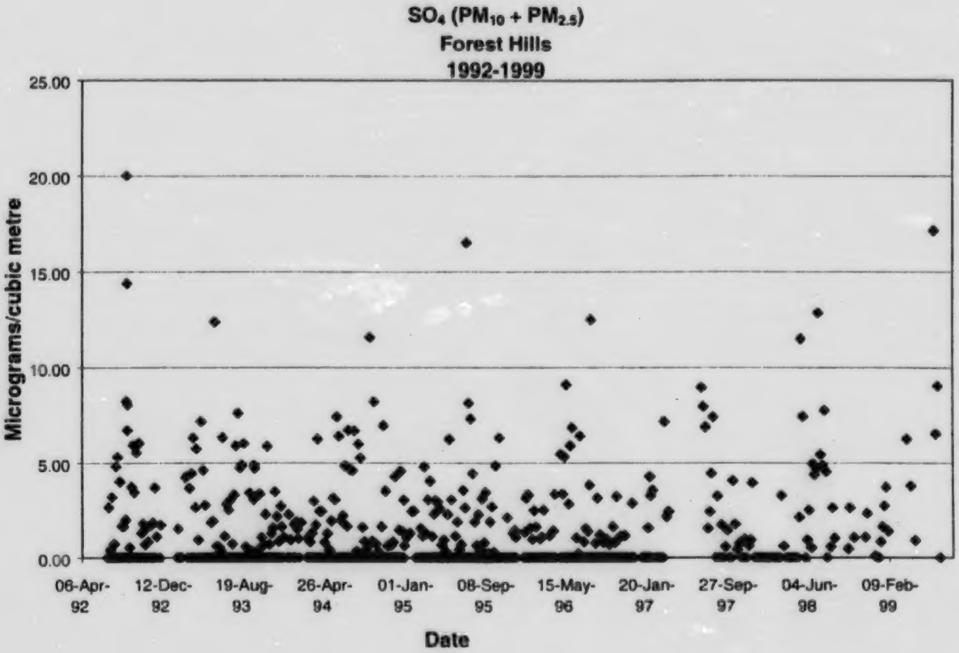


Figure 5. Sulphate (PM_{10} +$PM_{2.5}$) measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

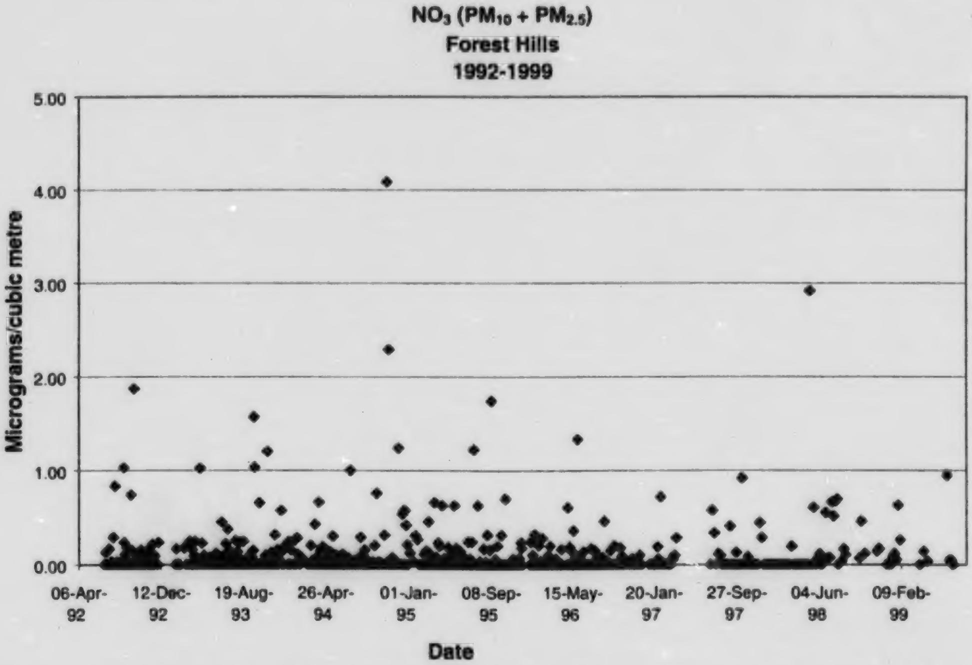


Figure 6. Nitrate (PM_{10} +$PM_{2.5}$) measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

A considerable scatter can be seen in the results for sulphate, together with an indication of higher values in summer, and no apparent overall trend. The results for nitrate are generally similar. High nitrate results appear to be less frequent in recent years, but this may be due to lower sampling frequency. The overall nitrate trend is flat.

Of the metals analysed in the dichotomous sampler program, some are of special interest as indicators of industrial or other human activity, including vanadium, nickel, chromium, manganese, iron, and lead. Results for these metals are summarised in the following charts.

Vanadium and nickel are often used as indicators of impact from heavy fuel oil burning, as these metals are found in relatively high concentrations in heavy oil. Both these metals are found predominantly in the fine ($PM_{2.5}$) particle fraction. Results since 1992 in Figures 7 and 8 appear to show a slight decreasing trend but again, this may be affected by changing sample frequency. Across the country, the sites with the highest nickel and vanadium concentrations include Montreal and Vancouver, with probable refinery influence in each case.

Chromium is often at or below detection levels, and is found mostly in the coarse (PM_{10}) size fraction. Nationally, a downward trend has been reported for chromium in particulate matter (Dann, 1994) and the Saint John data (Figure 9) appear consistent with this.

Manganese is of interest due to the use of motor fuel octane enhancers (such as methyl manganese tricarbonyl, or MMT) containing this metal. Manganese is found in both the fine and coarse particle fractions: the Saint John data since 1992 (Figure 10) indicate a falling trend, which is also seen at other Canadian sites. The reasons for this are not clear but could include changing refinery practices, reduced use of MMT in transportation fuels, and changes in industrial and transport emissions control technology.

Iron is found mostly in PM_{10} particulate and is highest in areas of heavy industrial activity: in Canada, Edmonton, Montreal and Windsor have the highest concentrations. The Saint John data for iron (Figure 11) show a reduction in values since 1992, and some indication of a tendency towards higher levels in summer.

Lead concentrations in particulate have fallen dramatically across the country with the phasing out of leaded gasoline in 1990, the main source in the ambient air. Lead is found almost entirely in the $PM_{2.5}$ size fraction of particulate matter. In the early 1980's, typical particulate lead levels were in the range 0.2 to 0.3 micrograms per cubic metre. Values now are well over ten times lower, and often near or at the detection limit. Saint John results for $PM_{2.5}$ lead (Figure 12) show a decline since 1992 and little change since 1996.

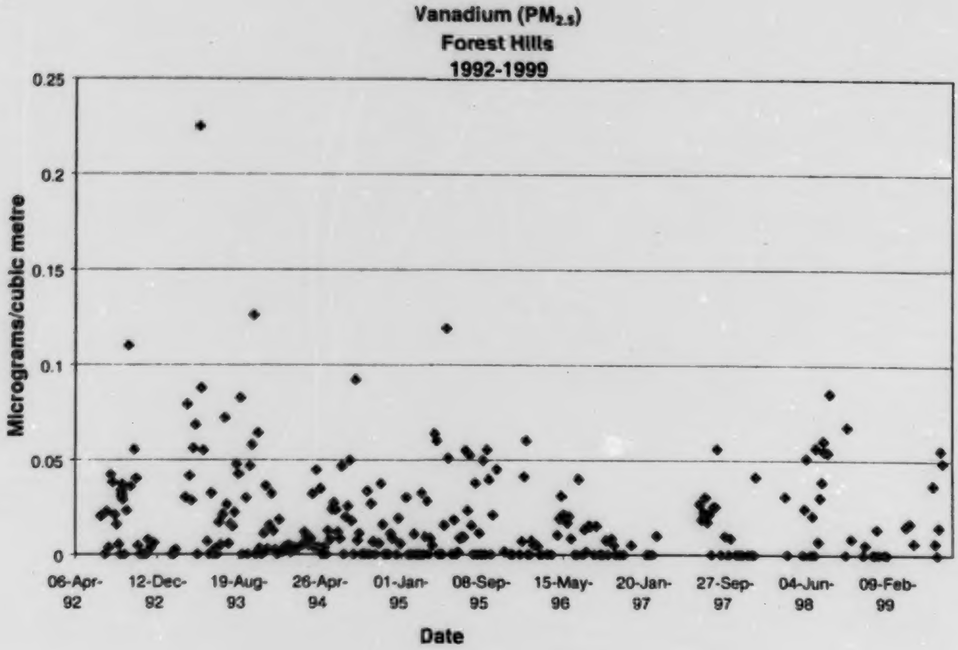


Figure 7. Vanadium in $PM_{2.5}$ particulate, measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

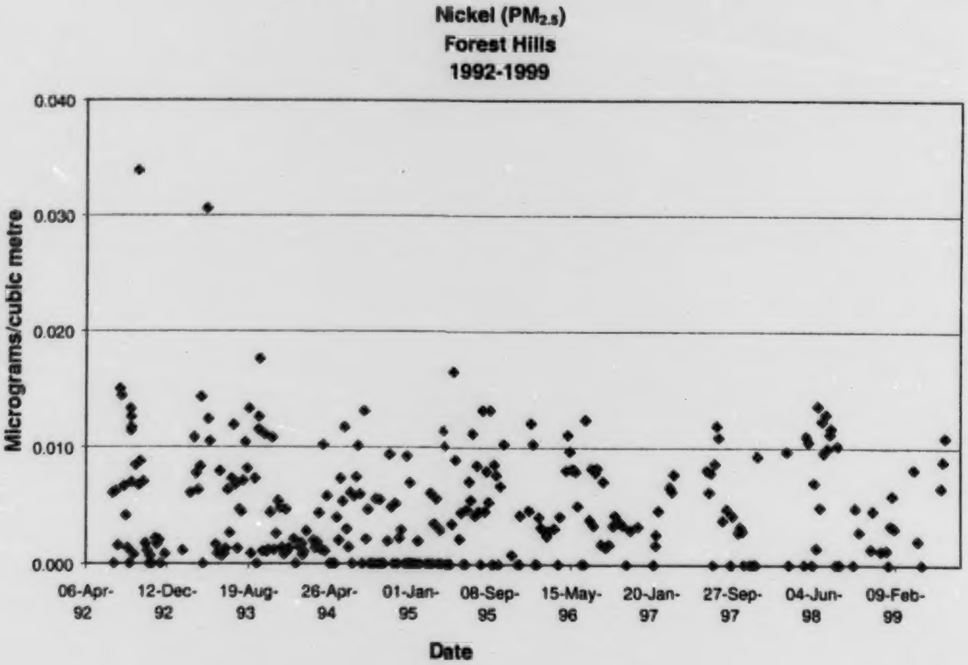


Figure 8. Nickel in $PM_{2.5}$ particulate, measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

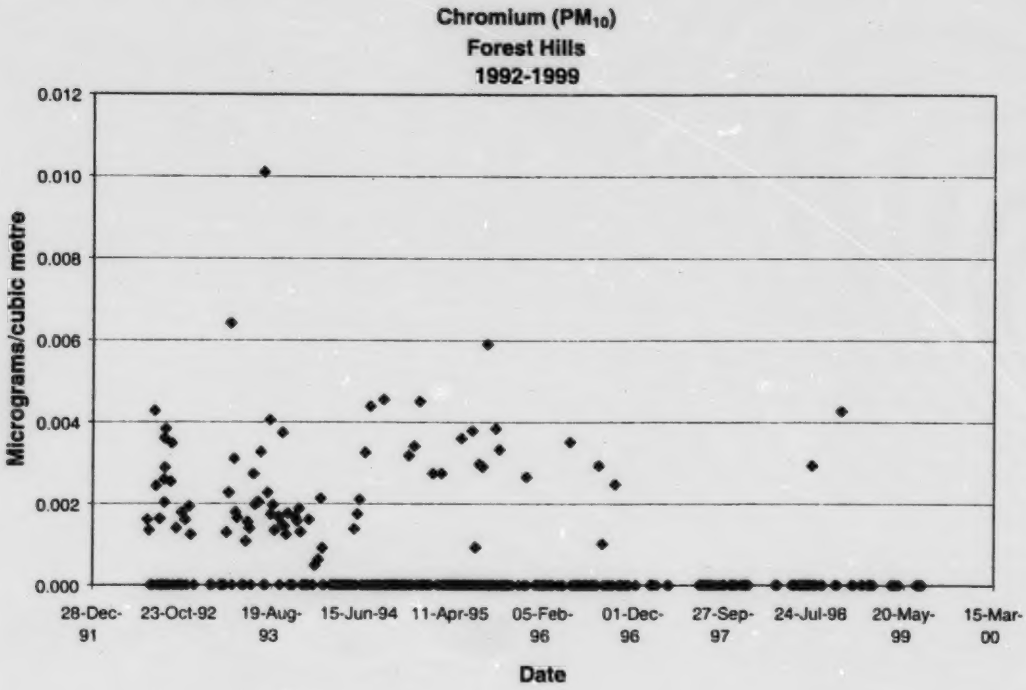


Figure 9. Chromium in PM_{10} particulate, measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

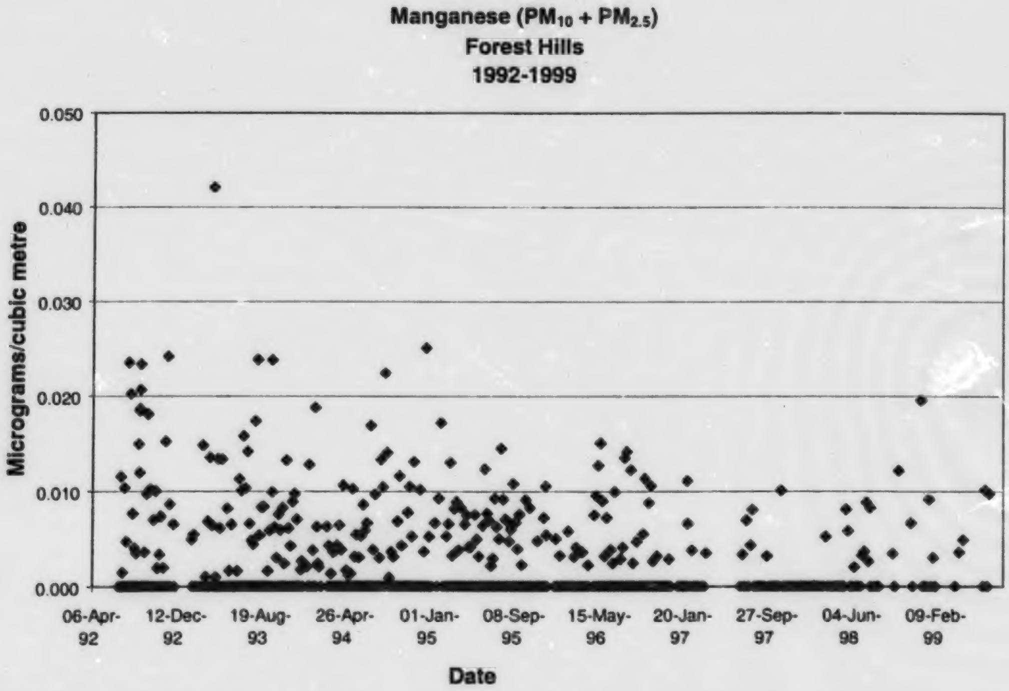


Figure 10. Manganese in $PM_{2.5}$ + PM_{10} particulate, measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

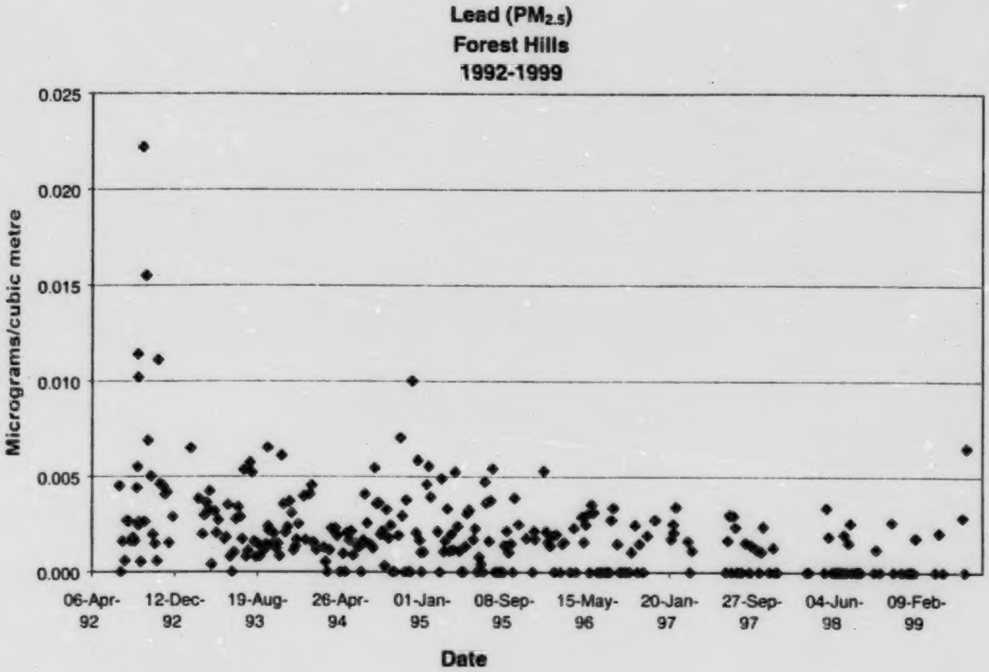


Figure 11. Iron in PM$_{10}$ particulate, measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

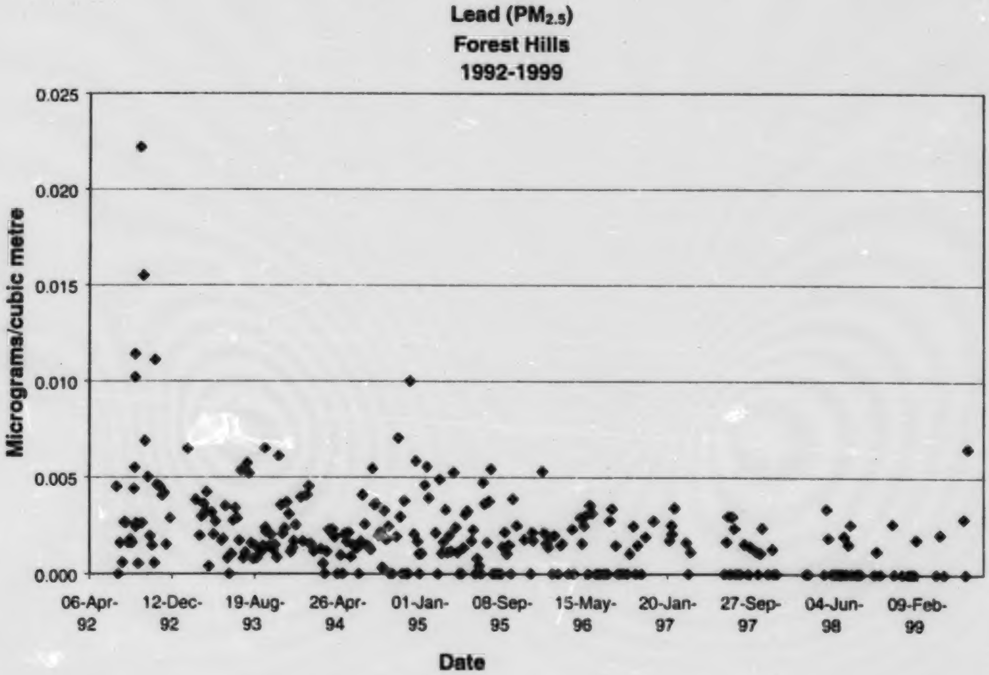


Figure 12. Lead in PM$_{2.5}$ particulate, measured by dichotomous sampler at Forest Hills, Saint John, 1992-1999.

A.6 Hydrogen Sulphide and Total Reduced Sulphur

Hydrogen sulphide and total reduced sulphur (TRS) are often treated together. These air pollutants are monitored at the Hillcrest site (NBDELG) as well as three sites operated by Irving Pulp and Paper (Milford, Indian Town and Sherbrooke St.).

There were a number of exceedances at these sites in 2000, as indicated in the following table. As a percentage of total hours, compliance was greater than 99% at all sites for both standards.

Exceedances of standards for Hydrogen Sulphide in 2000
Saint John (number of hours)

1-hour standard (11 ppb)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hillcrest	0	0	0	0	0	0	0	0	0	**3**	0	0	3
Sherbrooke	0	0	0	0	0	0	0	**3**	**1**	0	0	0	4
Milford	0	0	0	0	0	0	0	0	0	0	0	0	0
Indian Town	0	0	0	0	0	0	0	**2**	0	0	0	0	2
Total	0	0	0	0	0	0	0	5	1	3	0	0	9

24-hour standard (3.5 ppb)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hillcrest	0	0	0	0	0	0	0	0	0	18	0	0	18
Sherbrooke	0	0	0	0	0	0	0	6	23	0	0	0	29
Milford	0	0	0	0	0	0	0	0	12	0	0	0	12
Indian Town	0	0	0	0	0	0	28	19	0	0	0	0	47
Total	0	0	0	0	0	0	28	25	35	18	0	0	106

A.7 *Volatile Organic Compounds (VOCs)*

VOCs have been measured at Forest Hills in east Saint John since 1992. Measurements have also been made for the same period of time at Point Lepreau, approximately 40 km southwest of the city. The Lepreau site is predominantly upwind of Saint John and serves as a control or reference site, representative of rural southern New Brunswick. In July 2000, VOC sampling was begun at Champlain Heights in east Saint John. The monitoring program for VOCs is a collaborative one between NBDELG and Environment Canada. NBDELG staff maintain the monitoring sites and set up the equipment to take samples (normally every 6 days). Environment Canada performs the analyses on the collected air samples.

Sites in Saint John collect one 24-hour sample every 6 days and the rural site at Point Lepreau collects a 4 hour sample beginning at noon, every 3 days. These schedules are standard across Canada. All samples are analysed for over 150 compounds, including VOCs which are involved in the formation of ozone, as well as VOCs which may be of interest for other reasons. For example they may be indicators of various kinds of industrial activity, or they may be potentially of concern in their own right (for example substances which are known to be potentially carcinogenic, such as benzene). Some other VOCs which are measured are found at similar concentrations regionally or even globally (such as several CFC compounds). These substances are of key interest in atmospheric research.

There are no ambient air quality standards for VOCs in Canada. Results can be compared against guidelines published by other agencies, and examined over time to look for trends, as well as differences between sites.

The table on the following page lists results for 2000 for selected VOCs, compared with guidelines recommended by various agencies. This subset of VOCs contains compounds which have traditionally been classified as "air toxics", and which are considered potentially harmful to human health. The first line of the results table also shows the average concentration taking into account all VOCs measured at each site (total VOC). Results from the new sampling location at Champlain Heights were similar to, or in some cases higher than, those measured at Forest Hills. Both sites had higher concentrations of most VOCs than the Point Lepreau site.

For the selected VOCs for which guidelines could be referenced, concentrations at both monitoring sites were found to be below these targets at both sites, in most cases by a substantial margin. The substance with the smallest margin of "compliance" is benzene, comparing the annual average at Forest Hills and Champlain Heights (about 0.3-0.4 ppb) with the Swedish guideline (0.4 ppb). The annual guideline for benzene recently published in the United Kingdom (5 ppb) has a compliance target date of 2003, with the long-term target being a guideline of 1 ppb (EPAQS, 1994, HMSO, 2000). Benzene is emitted from motor vehicles and is a component of gasoline. In Saint John, the petroleum refinery and other industries would also contribute to ambient concentrations. Additional analysis of VOC data is included in the section on long-term trends (section 13).

2000 VOC Monitoring Results							
VOC	Max 24-h averages (ppb)		24-h guidelines (ppb) (WHO)	Annual averages (ppb)			Annual Guidelines (ppb)
	Forest Hills	Champlain Hts		Forest Hills	Champlain Hts	#Point Lepreau	
Total VOC	98.7	164.8		37.4	44.2	5.5	
1,3 butadiene	0.10	0.10		0.04	0.04	0.01	1 (UK)
Benzene	0.52	1.51		0.27	0.38	0.08	5(UK) 0.4 (Sweden)
Toluene	8.11	2.99	63*	2.85	1.03	0.18	10-100 (Sweden)
Ethylbenzene	0.26	0.60	4464*	0.13	0.21	0.02	
Xylenes	0.76	1.71	1013	0.35	0.61	0.04	
Styrene	0.34	0.69	56*	0.05	0.05	0.01	
Chloromethane	0.89	0.89		0.6	0.55	0.55	
Vinyl chloride	0.01	0.02		0.01	0.01	0.0	
1,1 dichloroethylene	0.02	0.02		0.01	0.01	0.0	
Dichloromethane	0.49	0.27	792	0.14	0.10	0.10	100-250 (Sweden)
1,2 dichloroethane	0.03	0.03	159	0.02	0.02	0.0	100-150 (Sweden)
Carbon tetrachloride	0.16	0.13		0.12	0.11	0.12	
1,2 dichloropropane	0.01	0.01		0.01	0.01	0.0	
Trichloroethylene	0.02	0.03		0.01	0.01	0.01	100-200 (Sweden)
1,1,2 trichloroethane	0.01	0.01		0.01	0.01	0.0	
Ethylene dibromide	0.01	0.01		0.01	0.01	0.0	
Tetrachloroethylene	0.05	0.03	34	0.02	0.02	0.0	
1,1,2,2 tetrachloroethane	0.01	0.01		0.01	0.01	0.0	
Formaldehyde	9.91	-		1.99	-	-	
Acetaldehyde	6.03	-		1.09	-	-	

Notes: The guidelines marked with an asterisk (*) are for a weekly period.
Sources: WHO (World Health Organisation): 1987, 1994,1996 & 1997; Swedish standards: OECD, 1995. UK standards: HMSO, 2000. # Data at Pt Lepreau are collected for 4 hours each sample day, starting at noon AST. The other sites are based on 24-h samples each sample day.

A.8 Index of the Quality of the Air (IQUA)

The IQUA system has been used in Saint John for 20 years to help make air quality monitoring results easier to understand. Results for each pollutant measurement are expressed on a scale from 1-100, and classed as "good" (index 0 to 25), "fair" (26 to 50), "poor" (51 to 100) or "very poor" (over 100). Each of the categories is based on the National Air Quality Objectives listed in Appendix II. For example, "good" air quality indicates that pollutants are in the "desirable" range as defined by the air quality objectives. Values in the "fair" range are above the desirable, but below the acceptable objective. IQUA information is distributed daily via the NBDELG web site: http://www.gov.nb.ca/scripts/environm/air/GetValues.idc

This web page is updated three times per day. IQUA information is also accessible by phone via recorded message (dial 636 4991 in the Saint John area). The recorded message is updated hourly.

For each hour, the IQUA index is computed for each pollutant measured at the site. The value reported is the highest of each of the individual values. For example if two pollutants are in the "good" range and one is in the "poor" range, then the index for the hour would be reported as "poor". In addition, the pollutant responsible for determining the overall index value is usually identified.

The IQUA System

National Air Quality Objective		IQUA Level
Exceeds Maximum Tolerable	VERY POOR	100 or more
Exceeds Maximum Acceptable	POOR	51-100
Exceeds Maximum Desirable	FAIR	26-50
Lower than Maximum Desirable	GOOD	0-25

Summary statistics are given in the following table for the three designated IQUA sites in Saint John: Customs Building (uptown), Forest Hills (east) and Hillcrest (west). The table shows the number of hours logged in each IQUA category. It is apparent that the vast majority of the time, air quality was in the "good" category during 2000 (from 98 to 99% of the time). The percentage of hours in the "fair" range was less than 3% at all sites, and there were no hours recorded in the poor or very poor categories.

IQUA Summary 2000: Saint John Sites

	Good (0-25)	Fair (26-50)	Poor (51-100)	Very Poor (over 100)
Forest Hills	99.7	0.3	0	0
Customs	99.4	0.6	0	0
Hillcrest	97.8	2.2	0	0

B. MIRAMICHI

There are two monitoring sub-networks in the Miramichi region, one centred on the REPAP pulp mill emission sources, and the other on NB Power's Millbank gas turbine generating site. Pollutants of concern in these networks include hydrogen sulphide and particulates (REPAP) plus nitrogen dioxide and sulphur dioxide (Millbank). Particulates are also measured at two sites operated by the Weyerhaeuser Company.

Figure 13 shows the locations of the five sites in the region.

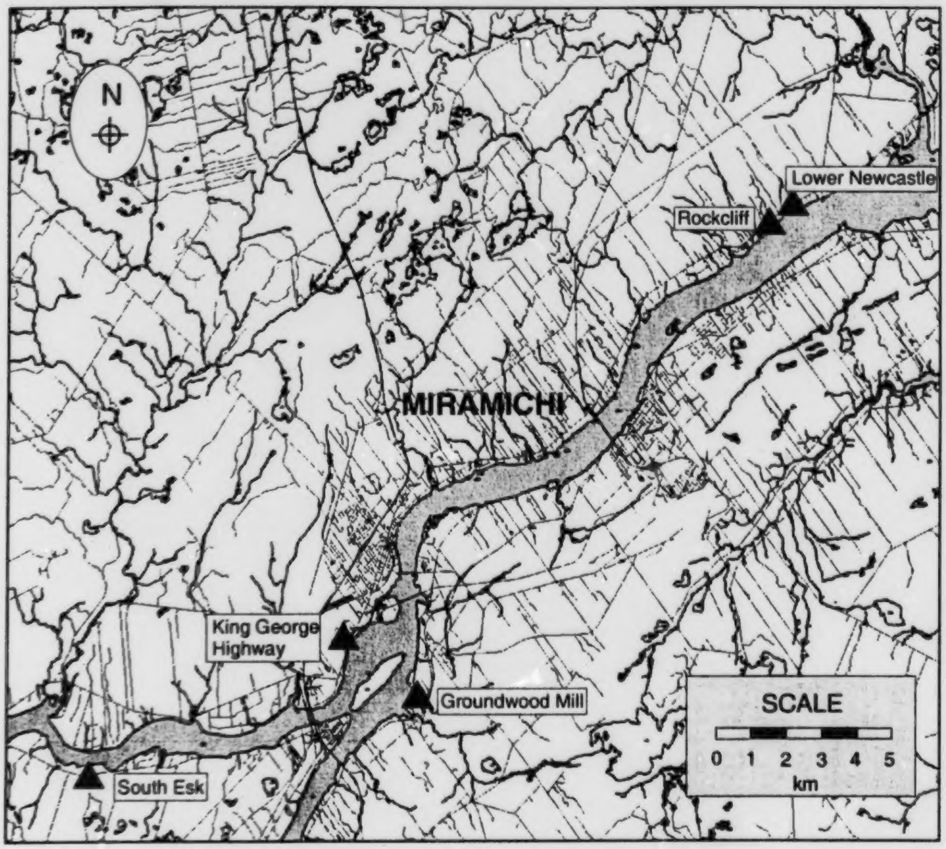

N
Lower Newcastle
Rockcliff
MIRAMICHI
King George Highway
Groundwood Mill
South Esk
SCALE
0 1 2 3 4 5
km

Figure 13. Air quality monitoring sites in the Miramichi Region.

B.1 REPAP NETWORK

B.1.1 Hydrogen Sulphide

Based on measurements for hydrogen sulphide at the Groundwood and King George Highway sites, the compliance summary for 2000 is as follows:

Exceedances of standards for Hydrogen Sulphide in 2000
REPAP sites (number of hours)

1-hour standard (11 ppb)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Groundwood	0	0	0	0	0	0	0	0	0	0	0	0	0
KG Highway	23	77	31	5	59	85	47	45	116	74	10	26	598
Total	23	77	31	5	59	85	47	45	116	74	10	26	598

24-hour standard (3.5 ppb)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Groundwood	0	0	0	0	0	0	0	0	0	0	0	0	0
KG Highway	112	248	108	4	170	300	214	175	415	310	44	119	2219
Total	112	248	108	4	170	300	214	175	415	310	44	119	2219

Exceedances: why they occur

Exceedances of air quality standards can occur for several reasons. For substances such as hydrogen sulphide, sulphur dioxide, nitrogen oxides, carbon monoxide and TSP, local emissions dominate. Exceedances for these contaminants may be due to emissions which are higher than usual, often together with unusual weather conditions. For example, winds blowing directly from an emission source (such as a smokestack) towards a monitoring site, or conditions when pollutants cannot disperse easily.

In the case of ozone, local emissions are far less important, and exceedances are dependent on weather patterns. Exceedances occur when winds bring ozone into New Brunswick from polluted regions beyond our borders (typically the northeastern US).

Exceedances of TSP often occur due to dust raised by the wind from roads. This often happens in April and May when surfaces dry out and roads and paths are still covered with fine sand from winter applications.

In 2000, compliance improved at the Groundwood site, and no exceedances were logged. A significant number of exceedances continued to be recorded at the King George Highway site. Compliance was attained for 93.2% of all hours (1-hour standard) and 74.7% of hours (24-hour standard), similar to what was seen in 1999.

Construction of the noncondensible gas collection and incineration system began in 2000. The system collects odorous gases from five major point sources at the mill for incineration in No.4 Power Boiler. Final installation will be completed during the spring 2001 maintenance shutdown, with startup following shortly thereafter. The conversion of the effluent treatment plant settling basins to aerated operation is well under way and is expected to go into operation in January 2001.

(Note REPAP became UPM-Kymmene in October, 2000).

B.1.2 Total Suspended Particulate

There were no exceedances of the TSP standard at any of the three monitoring sites during 2000. Detailed results are shown in Appendix III.

B.2 MILLBANK NETWORK

The two sites at Millbank (Rockcliff and Lower Newcastle, see Figure 13) are positioned to assess the impact of NB Power's gas turbine generating station. The pollutants monitored include sulphur dioxide, nitrogen dioxide and TSP.

B.2.1 Nitrogen dioxide

There were no exceedances of the 1-hour or 24-hour standards at either monitoring site in either 2000, and monthly means were all very low. Monthly results for 2000 are shown in Appendix III.

B.2.2 Sulphur dioxide

There were no exceedances of the 1-hour or 24-hour standards at either site in the network. The monthly means were also very low. This is both a reflection of the relatively infrequent operation of the Millbank plant, and the low sulphur fuel it uses. Monthly results are shown in Appendix III.

B.2.3 Total Suspended Particulate

None of the measurements made exceeded the 24-hour standard of 120 micrograms per cubic metre in 2000, and almost all were well below this value. All individual results are given in Appendix III.

B.3 Weyerhaeuser

B.3.1 Total Suspended Particulate

Weyerhauser operates a manufacturing plant for oriented strand board, located on the south shore of the Miramichi River, on the outskirts of Chatham. Two sites are maintained by this company for TSP, one at Morrison Cove and one in the Mirview Subdivision.

During 2000, there was one exceedance of the 24-h standard of 120 micrograms per cubic metre, at the Morrison Cove site. Data are summarised in detail in Appendix III.

C. Grand Lake - NB Power

Figure 14 shows the locations of the four monitoring sites in this network. These are sited to monitor the effects of the Grand Lake coal-fired electrical generating station and associated activities. The four monitoring sites are operated by NB Power and each measures sulphur dioxide and TSP.

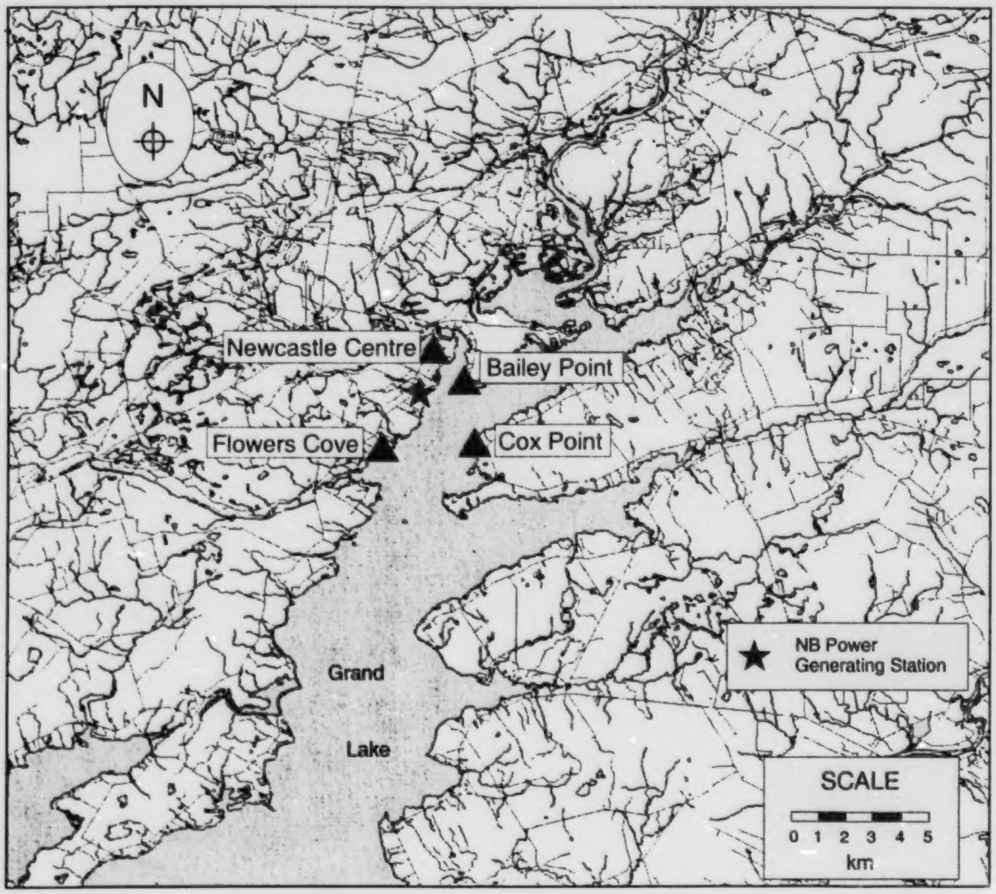

N
Newcastle Centre
Bailey Point
Flowers Cove
Cox Point
Grand
Lake
NB Power Generating Station
SCALE
0 1 2 3 4 5
km

Figure 14. Air quality monitoring sites in the Grand Lake Network.

C.1 Sulphur dioxide

Compliance was very good at all sites in 2000. There were two exceedances of the 1-h standard of 340 parts per billion, both at the Newcastle Centre site (one in March and one in September). The 24-h standard of 110 ppb was not exceeded at any site.

C.2 Total Suspended Particulate

In 2000, there were no exceedances of the 24-hour standard of 120 micrograms per cubic metre in this network. Complete results are given in Appendix III.

D. EDMUNDSTON – FRASER INC.

Figure 15 shows the locations of the two monitoring sites in the region (Cormier and Sacred Heart), located primarily to monitor the impacts of the Fraser Inc. pulp mill. At each site, sulphur dioxide and TSP are monitored.

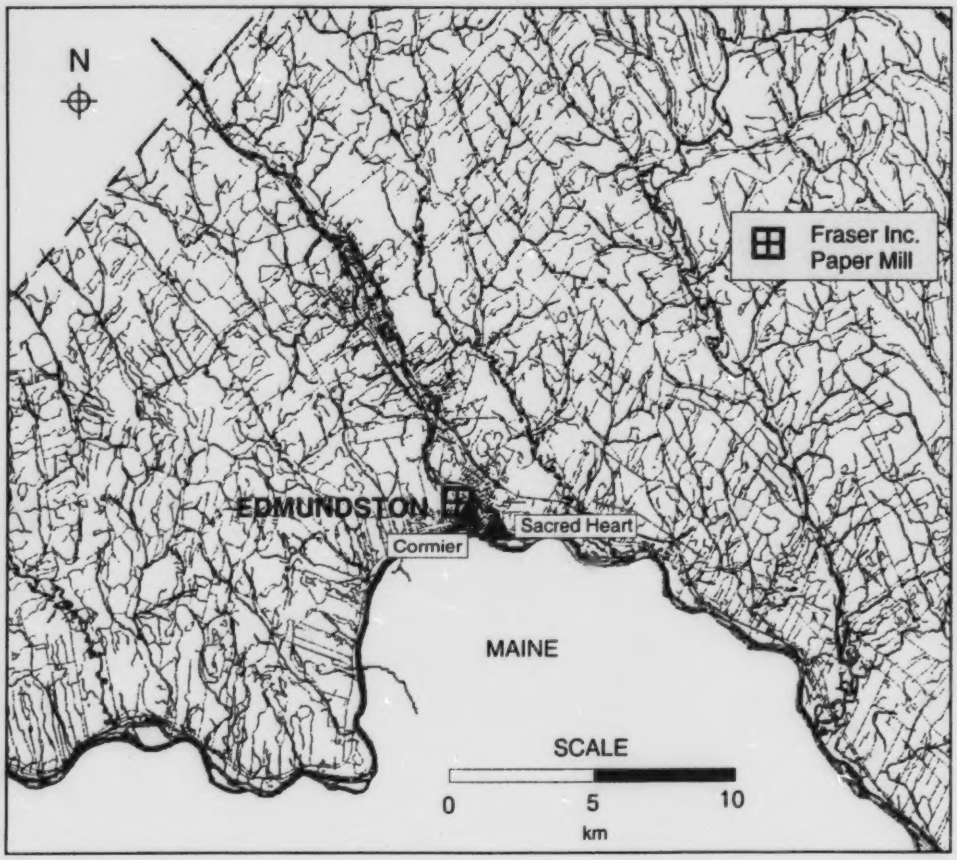

N
Fraser Inc. Paper Mill
EDMUNDSTON
Sacred Heart
Cormier
MAINE
SCALE
0
5
10
km

Figure 15. Air quality monitoring sites in the Edmundston network.

D.1 Sulphur Dioxide

There were two exceedances of the 1-hour standard at the Cormier site, one in January and one in April. There were no exceedances of the 24-h standard at either site during 2000. The Sacred Heart site was taken out of service in June due to a change in ownership of the land on which the site is located.

D.2 Total Suspended Particulate

There were 6 days on which the 24-hour standard of 120 micrograms per cubic metre was exceeded at the Cormier site, and two exceedances at the Sacred Heart site.

High TSP values generally occur in spring, when pulverised sand from winter road treatment is drying out and is raised by the wind.

Detailed results are shown in Appendix III.

D.3 $PM_{2.5}$ Particulate Matter

Continuous fine particulate measurements began at the Cormier site in June 2000. Hourly averages rarely exceeded 40 micrograms per cubic metre, and there were no 24-hour averages exceeding the Canada-Wide Standard of 30 micrograms per cubic metre. Detailed results are shown in Appendix III.

E. BELLEDUNE

There are a number of monitoring sites in the Belledune region. Four of these are located for the assessment of emissions from the Brunswick Mining and Smelting complex. A further five monitors are operated for the assessment of NB Power's coal-fired electrical generating station.

Figure 16 shows the locations of all the monitoring sites in the region.

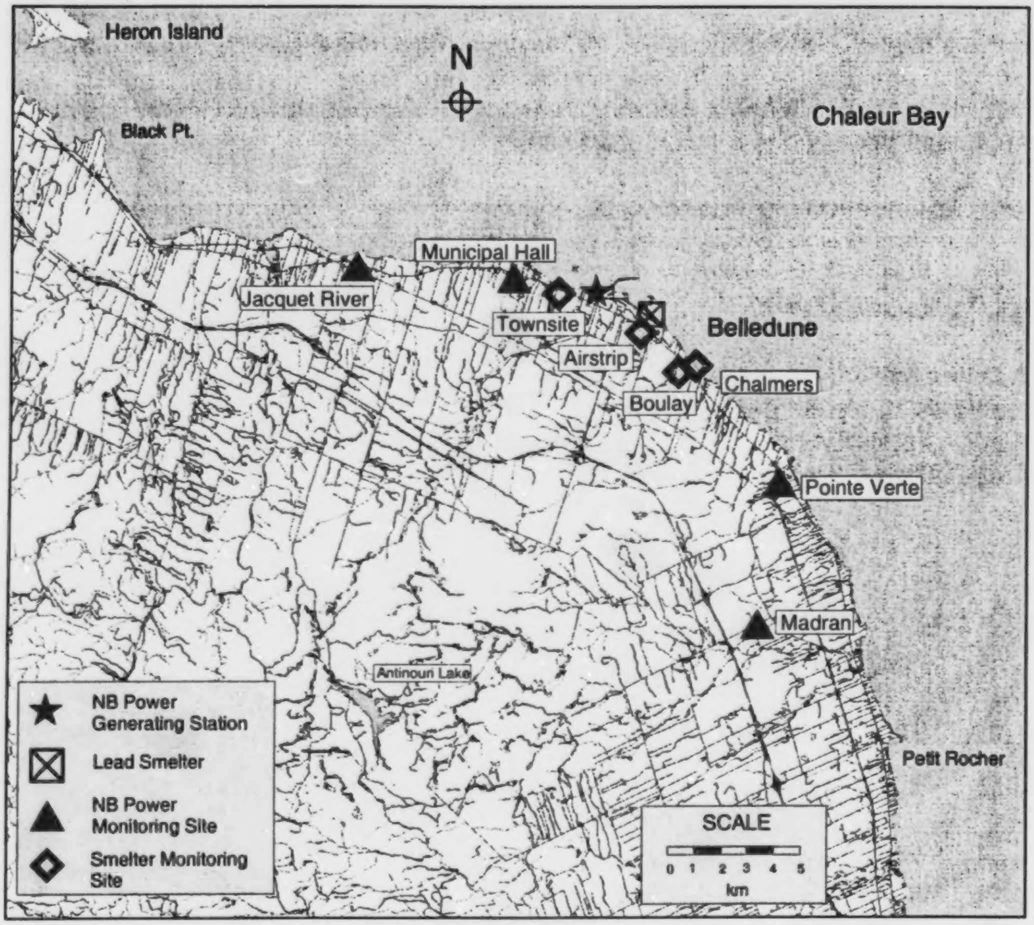

Heron Island
N
Black Pt.
Chaleur Bay
Municipal Hall
Jacquet River
Townsite
Airstrip
Belledune
Chalmers
Boulay
Pointe Verte
Madran
Antinouri Lake
Petit Rocher
NB Power Generating Station
Lead Smelter
NB Power Monitoring Site
Smelter Monitoring Site
SCALE
0 1 2 3 4 5
km

Figure 16. Air quality monitoring sites in the Belledune Network.

E.1. BRUNSWICK MINING AND SMELTING

All sites in the Brunswick Mining and Smelting network monitor sulphur dioxide, and three also measure TSP.

E.1.1 Sulphur dioxide

In 2000 there was a small number of exceedances of the 1-hour standard, as summarised below. The 1 hour standard is 34 pphm or 340 ppb.

There were no exceedances of the 24-hour standard (11.3 pphm or 113 ppb) at any station.

Exceedances of the 1-hour sulphur dioxide standard in 2000
Brunswick Mining and Smelting, Belledune (number of hours)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Airstrip	3	0	0	0	0	1	0	0	0	0	0	0	4
Chalmers	0	0	0	0	0	1	0	0	0	0	0	0	1
Townsite	0	0	0	0	0	0	1	0	0	0	0	0	1
Boulay	0	1	0	0	0	1	0	0	0	0	0	0	2
Total	3	1	0	0	0	3	1	0	0	0	0	0	8

The 1 hour standard is 34 pphm or 340 ppb.

E.1.2 Total Suspended Particulate

During 2000 there was one exceedance of the 24-hour standard at the Airfield site and one at the Townsite location. Complete results are summarized in Appendix III.

E.2 NB POWER

There are five sites in this network, all of which monitor for sulphur dioxide. Two sites also monitor nitrogen dioxide.

E.2.1 Sulphur dioxide

During 2000 there were three exceedances of the 1-h standard, as summarised below.

Exceedances of the 1-hour sulphur dioxide standard in 2000
NB Power Network, Belledune (number of hours)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Madran	0	0	0	0	0	0	0	0	0	0	0	0	0
Pointe Verte	0	0	0	0	0	0	0	0	0	0	0	0	0
Belledune E	1	1	0	0	0	0	0	0	0	0	0	0	2
Jacquet River	0	0	0	0	0	0	0	0	0	0	0	0	0
Municipal Hall	0	0	0	0	0	0	0	0	0	0	0	1	1
Total	1	1	0	0	0	0	0	0	0	0	0	1	3

The 1 hour standard is 34 pphm or 340 ppb.

In 2000 there were no exceedances of the 24-hour standard of 113 ppb at any site.

E.2.2 Nitrogen dioxide

This contaminant is measured at Belledune East and Municipal Hall. There were no exceedances of the applicable 1 or 24-hour standards in 2000 at either location.

F. DALHOUSIE - NB POWER

Figure 17 shows the locations of the sites in the region. The sites in this region are operated to monitor the effects of the NB Power Dalhousie electrical generating station. Eight sites measure sulphur dioxide; one of the eight also monitors for TSP, and there is one additional TSP site (9 sites in all). Because of potential pollution transport across the Bay of Chaleur, three of the eight stations are located in the province of Québec.

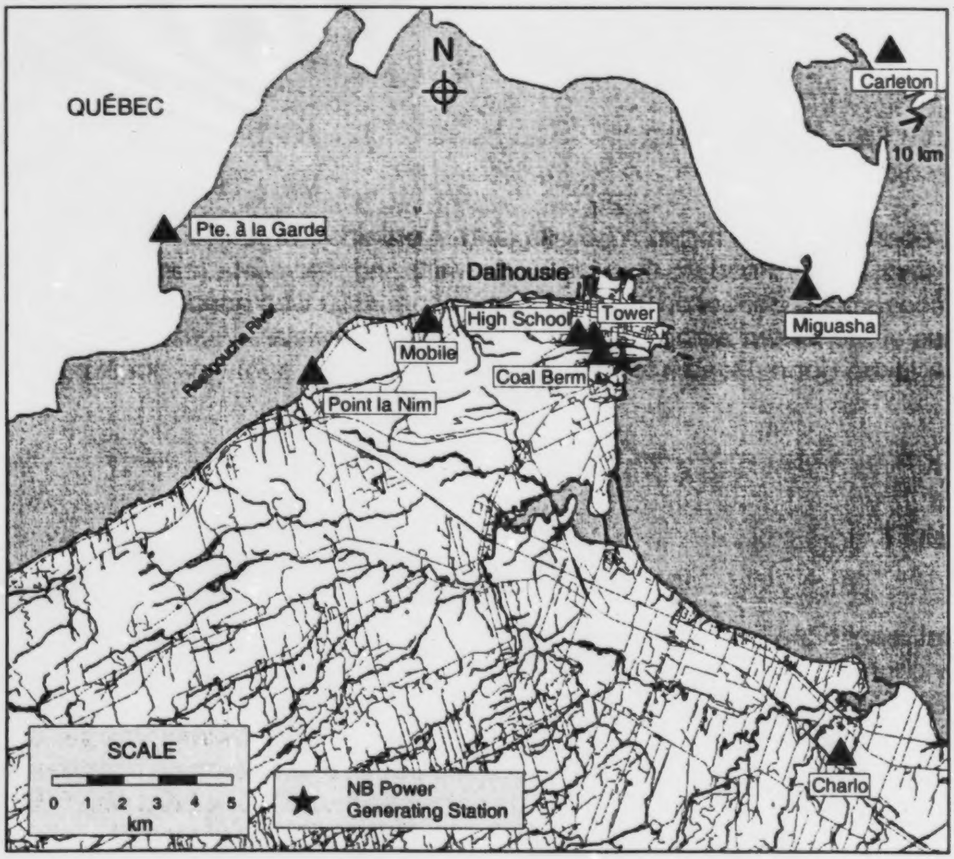

QUÉBEC
N
Carleton
10 km
Pte. à la Garde
Dalhousie
High School
Tower
Miguasha
Mobile
Coal Berm
Point la Nim
Restigouche River
Charlo
SCALE
0 1 2 3 4 5
km
★ NB Power Generating Station

Figure 17. Air quality monitoring sites in the Dalhousie Network.

F.1 Sulphur dioxide

Compliance with the applicable 1-hour and 24-hour standards was 100% at all sites in 2000, as it was in 1999. Detailed summaries are given in Appendix III.

F.2 Total Suspended Particulate

TSP was measured at the Coal Berm and Dalhousie Tower sites. Results are shown in Appendix III. None of the individual readings obtained were above the 24-hour standard of 120 micrograms per cubic metre in 2000, and the annual geometric means were also well below the standard of 70 micrograms per cubic metre.

G. ATHOLVILLE - AV CELL INC

G.1 Sulphur dioxide

AV Cell Inc operates a pulp mill in Atholville, and maintains two associated ambient air monitoring sites, Boom Road (to the west of the mill) and Beauvista (east). Sulphur dioxide is measured at both sites. Compliance during 2000 was good, with no exceedances of the 1-hour standard (340 ppb) at the Beauvista site and one exceedance at the Boom Road site. The 24-h standard (113 ppb) was not exceeded at either site.

H. BATHURST

H.1 $PM_{2.5}$

The Bathurst monitoring station is located off St Peter Avenue, on the grounds of the Holy Family church. A TEOM monitor for $PM_{2.5}$ particulate matter is operated at this site by NBDELG. Results for 2000 showed that $PM_{2.5}$ concentrations were low in comparison to other sites, with very few hourly readings over 30 micrograms per cubic metre. The annual 98th percentile value, which will be used to determine compliance with the CWS for $PM_{2.5}$, was 13.6 micrograms per cubic metre (compared with the CWS criterion of 30 micrograms per cubic metre). A detailed summary of monthly data appears in Appendix III.

I. FREDERICTON

The Fredericton site is on Aberdeen Street, in an area representative of the "downtown" residential and business district. The site is also considered representative of a wider area for pollutants such as ozone, which are regional in nature.

I.1 Carbon monoxide

No exceedances of the 1-hour or 8-hour standards (respectively 30 ppm and 13 ppm) were recorded. Values were higher in the fall and winter months than during the summer, but even then, peak hourly readings were less than 10% of the standard.

I.2 Nitrogen dioxide

No exceedances of the 1 or 24-hour standards (210 ppb and 105 ppb) were recorded. As for carbon monoxide, higher readings were seen in the cooler months, but levels remained low. The highest hourly readings were about 20% of the standard.

I.3 Ground level ozone

There were no exceedances during 2000 of the national 1-hour objective for ozone. There were 4 hours in exceedance of the new Canada-Wide Standard of 65 ppb (8-h average), in July. Overall during 2000, ozone levels were low across New Brunswick, when compared with previous years. There is additional discussion of data from the ozone network in section 11.

I.4 Total suspended particulate

The monitoring site for TSP is at the fire hall on the corner of York and Dundonald streets. There were four readings in 2000 which exceeded the 24-hour standard of 120 micrograms per cubic metre. As in 1999, these high values are thought to be due to construction activity at the adjacent York/Dundonald intersection.

I.5 $PM_{2.5}$ Particulate matter

Fine particulate matter ($PM_{2.5}$) was measured at the Aberdeen St site using a TEOM instrument, which provides a continuous record of particulate concentrations. Data obtained during 2000 indicated generally moderate to low particulate concentrations. There were no exceedances of the Canada-Wide Standard, a 24-hour average of 30 micrograms per cubic metre. The 98th percentile value for 2000 was 18.0 micrograms per cubic metre, down from 22.7 in 1999.

I.6. Index of the Quality of the Air

Results for 2000 showed air quality in the "good" category for 99.4% of the time, with the remainder (0.6%) in the "fair" range. Ozone was responsible for the small number of hours in the fair range. Results were made available hourly via recorded voice message at 451 6000.

J. NACKAWIC

The St. Anne-Nackawic Pulp Company Ltd established an ambient air monitoring site during 1999, as required by the Air Quality Approval issued by the NBDELG. Sulphur dioxide, total reduced sulphur (TRS) and total suspended particulate (TSP) are measured, as well as wind speed and direction.

Compliance was 100% for sulphur dioxide during 2000. For TRS, there were six exceedances of the 1-h standard of 11 ppb (in Feb, May, Aug Sep and Oct). These exceedances were of short duration and there were no exceedances of the 24-h standard of 3.5 ppb. The results for TSP showed low concentrations and no exceedances were recorded.

K. MONCTON

The Moncton air quality monitoring site is situated at the Highfield Street water pumping station. The site location was chosen to provide readings representative of the central city suburbs, in areas which may be influenced by emissions from vehicles or institutional heating systems, as well as regional pollutants such as ozone.

K.1 Carbon monoxide

No exceedances of hourly or 8-hourly standards for carbon monoxide occurred during 2000. Readings were similar to those recorded in downtown Saint John, and although slightly higher than those in Fredericton, were still well below standards.

K.2 Nitrogen dioxide

No exceedances of hourly or 24-hourly standards for nitrogen dioxide were recorded during 2000. Maximum hourly values were less than 20% of the standard.

K.3 Ozone

Ozone levels were low in 2000 and no exceedances were recorded of the hourly objective for ozone or the new Canada-Wide Standard. More discussion of ozone data may be found in section 11.

K.4 $PM_{2.5}$ Particulate matter

$PM_{2.5}$ sampling using a continuous TEOM analyzer began in November 1999. The 2000 results revealed low concentrations, with few hourly values over 30 micrograms per cubic metre ($\mu g/m^3$). The 98th percentile value for the year was 15.1 $\mu g/m^3$, compared to the CWS criterion of 30 $\mu g/m^3$.

K.5 Index of the Quality of the Air

Hourly IQUA reports are generated for the Moncton site and made available via recorded message at 851 6610. Summary statistics for 2000 indicate that good air quality was recorded for 99.5% of all hours in 2000, and fair for just 0.5%.

L. ST. ANDREWS

The St. Andrews monitoring station is located on the grounds of the Huntsman Marine Science Centre and is operated with the support of staff from the Centre and NBDELG. This site has been used for a variety of special sampling projects and is especially suitable for investigating trans-boundary air pollution. Currently, projects operated at St Andrews by the province include ozone and $PM_{2.5}$ monitoring. Additionally, mercury concentrations in air and precipitation, plus toxic organic compounds in air are also monitored at this site, in collaboration with Environment Canada. This is the only location in the province where these kind of measurements are made, and one of only two in the Maritimes.

L.1 $PM_{2.5}$ (TEOM)

The St Andrews TEOM unit collected valid data for over 99% of the year during 2000. In general, readings were very low at this site, hourly values seldom exceeded 30 micrograms per cubic metre, with the majority below 15 micrograms per cubic metre. The new Canada-Wide Standard of 30 micrograms per cubic metre (24-h average) was not exceeded at any time during the year. The 98th percentile value for the year (based on 24-hour averages) was 15.5 micrograms per cubic metre.

L.2 Mercury monitoring

Mercury is of concern as an environmental contaminant because of its ability to accumulate in living organisms, potentially reaching concentrations which could pose a hazard to health in humans and wildlife (e.g. NESCAUM, 1998). Although mercury has been recognised as an environmental pollutant for decades, relatively little monitoring and assessment of the transport and behaviour of mercury in the atmosphere has taken place. Most attention has been paid to direct discharges, for example of industrial, water-borne effluents. Recently, the New England Governors and Eastern Canadian Premiers identified mercury as a substance of concern in the east of Canada and the United States, and developed an Action Plan to improve our understanding of its impacts, as well as proposing measures to reduce man-made emissions (NEGECP, 1998).

Mercury monitoring conducted at St Andrews contributes to the scientific understanding of mercury in the environment. The results are used in research (for example into atmospheric processes) as well as in wildlife and other studies.

The following table summarises results of the mercury monitoring program so far. These monitoring studies are operated cooperatively between Environment Canada, the Huntsman Marine Science Centre, and NBDELG.

Mercury Monitoring Results 1995-2000			
Ambient Air			
St Andrews		Other sites	
Year	Annual Average (ng/cubic metre)	Site	Annual averages (ng/cubic metre)
1995	1.9	Mt Mansfield, VT	2.0 (94-96)*
1996	1.5	Kejimkujik, NS	1.5 (1996)*
1997	1.4	Westfield, NY	2.6 (94-96)*
1998	1.4	Moss Lake, NY	2.4 (94-96)*
1999	1.6		
2000	1.4		
Precipitation (rain and snow)			
Year	Mean mercury concentration (ng/L)	Kejimkujik, N.S.	Mean mercury concentration (ng/L)
1996	7.5**	1996	7.4**
1997	6.7**	1997	5.9**
1998	5.8**	1998	5.2**
1999	6.5**	1999	5.0**
2000	6.5**	2000	4.7**
Notes: ng = nanograms. 1 nanogram is one thousand-millionth of a gram. Ambient air mercury data supplied by Environment Canada.		References: * NESCAUM (1998) ** NADP (2000)	

There are no environmental guidelines or objectives for mercury in air or precipitation at present. The data may be used to look for patterns or trends over time, and to compare regionally with other locations. They are also used as input to ecological models which attempt to track how mercury moves though different components of the environment.

The results show several things. In ambient air, the concentration of mercury in vapour form varied between approximately 1.5 and 2 nanograms per cubic metre as an annual average. These values are similar to those measured in Nova Scotia and rural southern Quebec, and lower than readings obtained at sites in parts of New England or southern Ontario, which typically range from 2 to 3 nanograms per cubic metre (NESCAUM, 1998). Over the course of a year, readings at St. Andrews tend to be highest in late winter and lowest in late summer. The reasons for this have not yet been fully explored, but the changing use of fossil fuels through the year is thought to be a major influence (NESCAUM, 1998).

Considering mercury measurements in precipitation, the trends seen at St. Andrews and at Kejimkujik in southwestern Nova Scotia, are similar. Mercury concentrations have generally fallen at both sites since 1996. However at St Andrews, there was an increase from 1998 to 1999 (sustained in 2000) and results from St. Andrews are consistently higher than those from the Nova Scotia location. A detailed examination of results shows that the two sites occasionally exhibit significant differences in mercury concentrations for the same precipitation episodes.

L.3 Semi-volatile organics

An ambient air measurement program for various organic compounds has been operated at the St Andrews site since December 1994. Two main classes of organic compounds are sampled in this program: PAHs, or polycyclic aromatic hydrocarbons, and PCDDs/PCDFs, or polychlorinated dibenzo-p-dioxins and dibenzofurans. Both of these groups of organic compounds are of interest due to their toxicity. The semi-volatile organics monitoring program is a joint project with Environment Canada, who provide analytical services from the Environmental Technology Centre laboratory in Ottawa. This national monitoring program has 35 sites across Canada. In the Atlantic Region, sites are located at St Andrews, NB, Kejimkujik and Halifax, NS, and Charlottetown, PEI. A sampler was also operated at Forest Hills, Saint John, during 1995 only.

Sampling is carried out using modified high-volume air samplers. Samples are collected over a 24-hour period once every two weeks. The filters and pre-cleaned foam cartridges used to capture both particulate matter and organic compounds in vapour form. The filters and foam inserts are shipped to the Ottawa lab for extraction and analysis.

Dioxins and furans are persistent and bio-accumulative in the environment. They may cause a variety of adverse heath effects including cancer (e.g. LaGrega, Buckingham and Evans, 1994). PAHs have a variety of sources. The largest source type is combustion, including biomass, fossil fuels and waste incineration.

SOURCES OF PAH EMISSIONS IN CANADA		
Source	**Tonnes/year**	**% of total**
Forest Fires	2 008	45.8
Aluminum smelting	925	21.1
Residential wood burning	474	10.8
Woodwaste burning	249	5.7
Transportation-diesel	155	3.5
Transportation -gasoline	45	1.0
Other sources	530	12.1
Total	**4 386**	**100.0**
Source of data: Lalonde et al., (1993)		

The current measurement program analyses for 28 different PAHs, many of which are designated as toxic substances of special concern within Canadian federal legislation (e.g. under the Canadian Environmental Protection Act), and by other agencies such as the UNECE, the US Environmental Protection Agency, and the International Joint Commission.

Dioxins and furans are also emitted from combustion sources, the largest of which are medical and municipal waste incinerators and metal smelters. Similarly to PAHs, a variety of other combustion sources account for the balance of the emissions total. In this program, 17 dioxin and furan compounds are measured.

Both PAHs and dioxins/furans are found in air at extremely low concentrations, in the range of nanograms to picograms per cubic metre. These concentrations are from one thousand to one million times lower than those typically observed for pollutants such as sulphur dioxide in an industrial area.

L.4 PAH Results

Results are presented in chart form for total PAH, benzo(a)pyrene, benzo(b)&(k)fluoroanthene and indeno(1,2,3-cd)pyrene, All data are presented in nanograms per cubic metre. Figure 18 shows results for total PAH, which is the sum of all 28 PAH compounds measured. Data gathered at the Saint John site in 1995 are also included for comparison. Each plotted point is the result for one 24-hour sample. Since 1995, levels have apparently fallen, and have been almost always less than 5 nanograms per cubic metre since 1997. St Andrews is classified as a "rural remote" site, and results are comparable to those obtained at similar sites in the network, such as Kejimkujik, Nova Scotia, Gray, Saskatchewan (south of Regina), and Point Petre, Ontario (on the eastern shoreline of Lake Ontario). Results from urban sites, and those known to be influenced by major industrial sources, are typically higher by a factor of from 4 to 20 (Dann, 1998). Figures 19, 20 and 21 present results for benzo(a)pyrene, benzo(b)&(k)fluoroanthene and indeno(1,2,3-cd)pyrene.

For each of these PAH compounds, levels have fallen over the period of record. PAH concentrations measured at St Andrews are among the lowest observed in Canada. Levels at urban sites tend to be elevated over those in rural situations. The highest PAH readings are found in areas influenced by large industrial point sources such as Jonquière, Québec (aluminum smelting), or Hamilton, Ontario (steel working). However, very high levels are also seen in Whitehorse, Yukon, largely due to high concentrations of wood smoke (Dann, 1998).

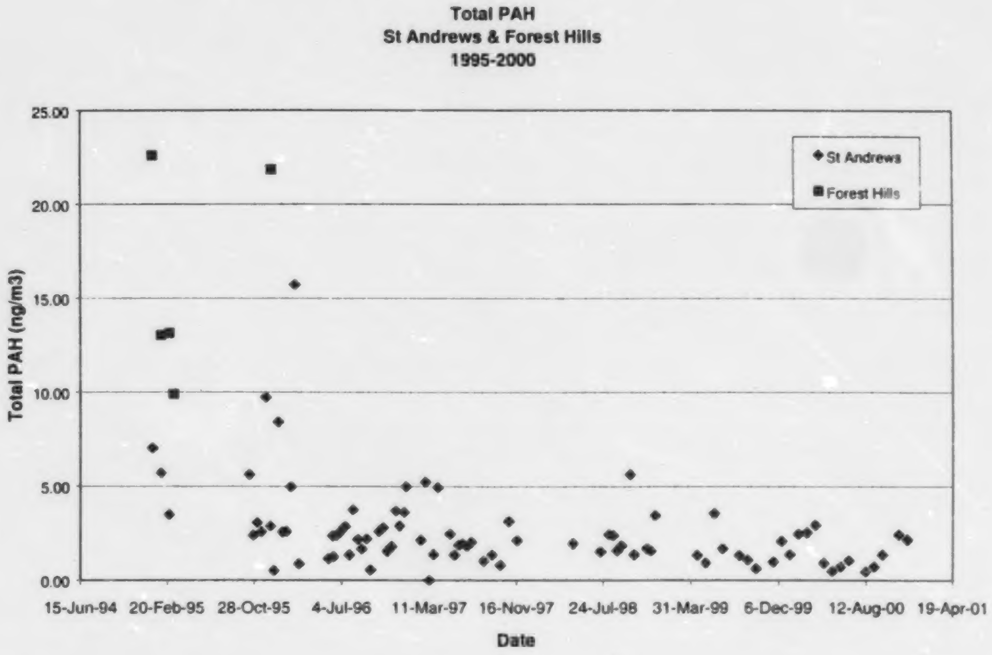


Figure 18. Total PAH at St Andrews and Forest Hills, 1995-2000.

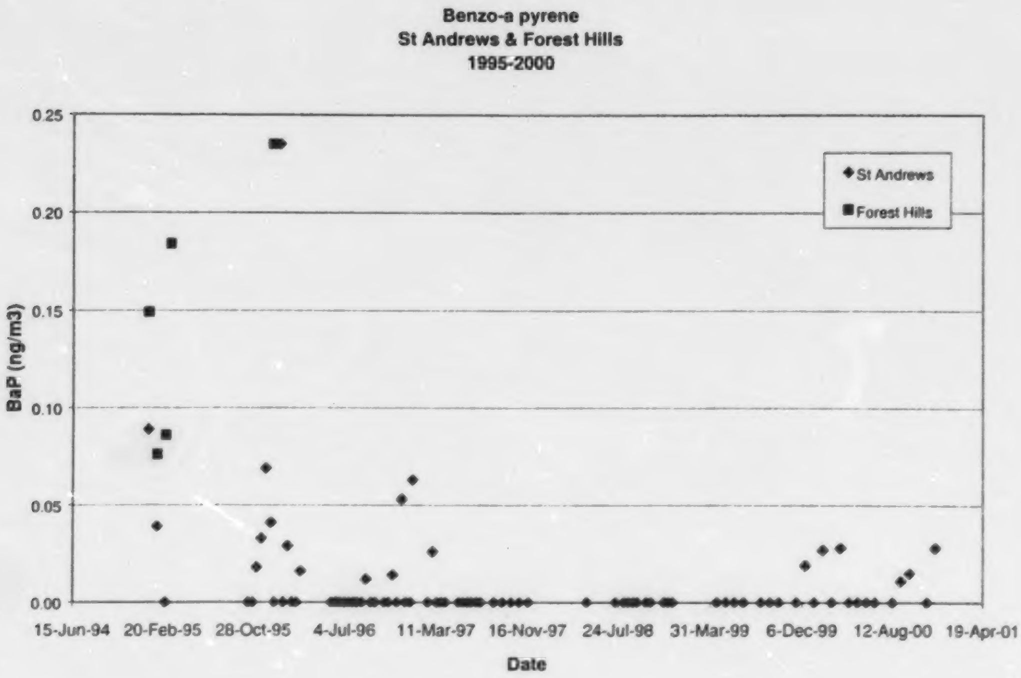


Figure 19. Benzo(a)pyrene at St Andrews and Forest Hills, 1995-2000.

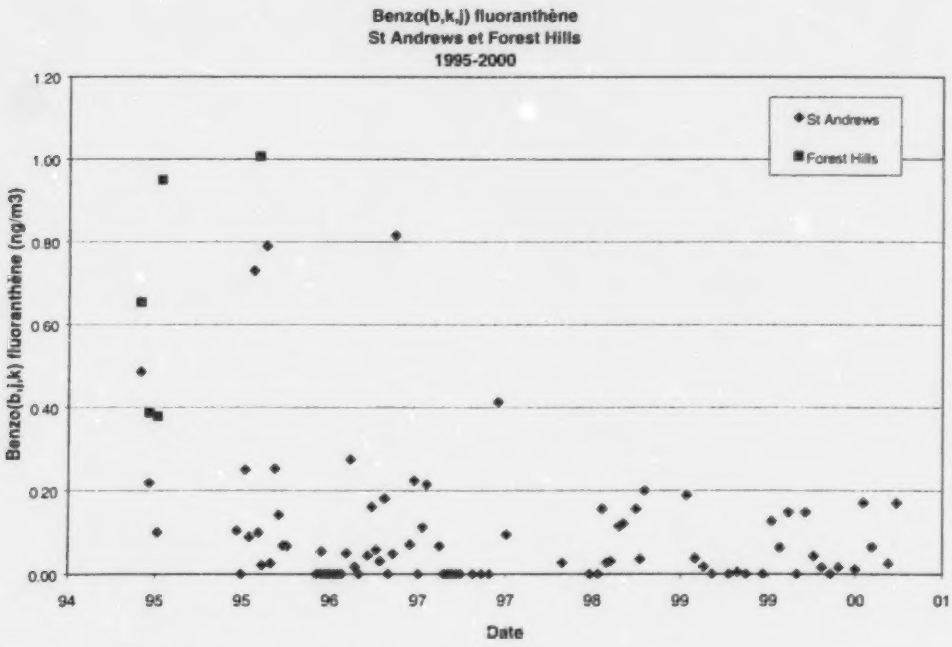


Figure 20. Benzo(b+k)fluoroanthene at St Andrews and Forest Hills, 1995-2000.

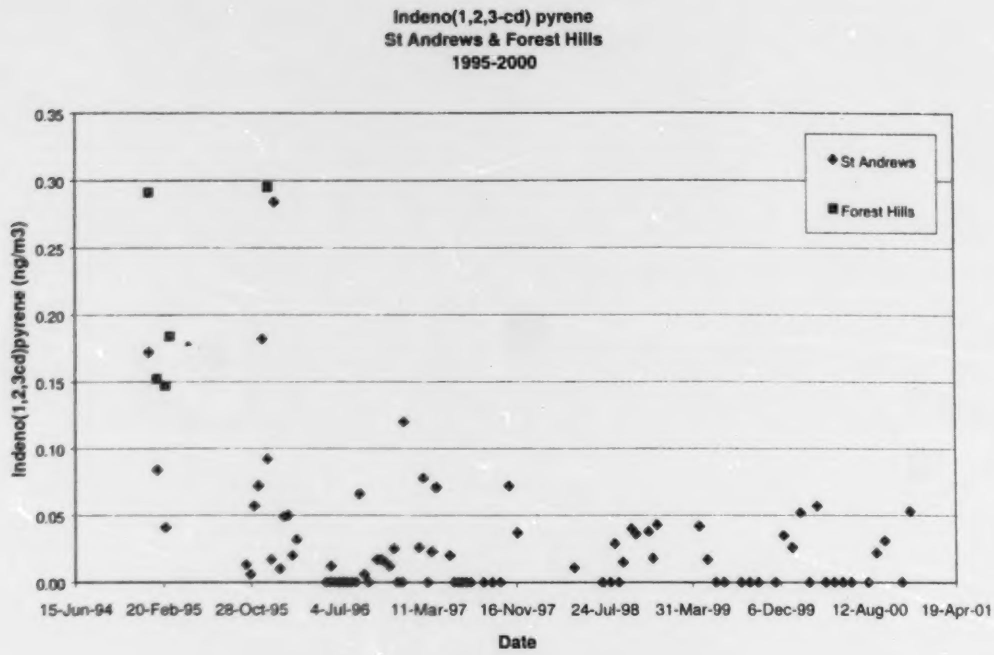


Figure 21. Indeno(1,2,3-cd)pyrene at St Andrews and Forest Hills, 1995-2000.

A decreasing trend is indicated by the St Andrews data since 1995. The reasons for this are speculative given the relatively small dataset, but could indicate a change in the operation of a combustion source in the vicinity of the monitoring site. The 5 readings from the Saint John site are higher than the majority of St Andrews results. This would be expected given the industrial setting of the Saint John site. However, the Saint John data overlap with the St Andrews results in the early part of the record. Winter values appear slightly higher than those obtained at other times of year, which would be consistent with woodsmoke effects.

Figure 22 shows an example of variation across the country for one key indicator PAH, benzo(a) pyrene, based upon data from 1994 to 1997. Both mean and median values are shown. Mean values may be biased by occasional peak readings, and medians are a better indicator of central tendency for this kind of information. Note also the number of samples available for each site. For some sites, fewer than 10 samples were available. Caution is needed when interpreting such results, which may not be representative of the true long-term trend. The chart shows that the highest average concentrations (such as at Whitehorse and Jonquière) are about 500 times higher than the lowest (such as those seen in the Maritimes and rural Prairie sites). A similar variation is seen for many other PAH compounds.

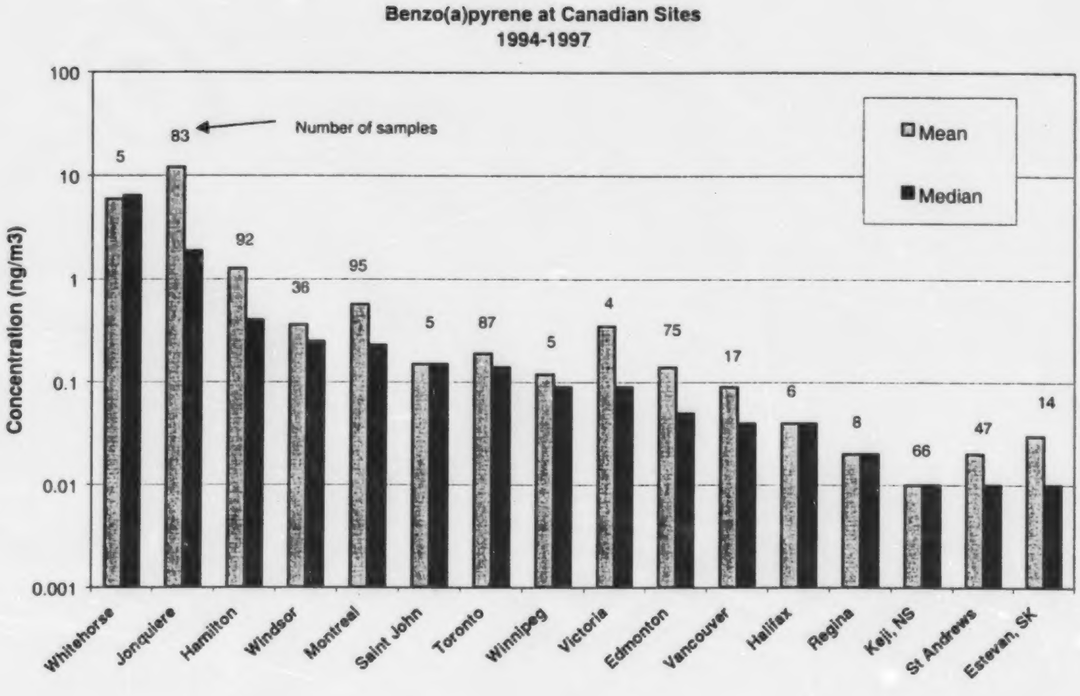


Figure 22. Benzo(a)pyrene at sites across Canada, 1994-1997. Numbers in the chart indicate the number of samples collected at each site.

L.5 PCDD/PCDF Results

Figure 23 summarises the PCDD/PCDF data gathered at St Andrews since 1994. Each point on the chart represents a 24-hour sample. As for PAHs, a range of different dioxins and furans is measured. It is a convention to present dioxin and furan data in terms of TEQ, or toxic equivalents. This compares the toxicity of each individual dioxin or furan to 2,3,7,8, TCDD, or tetrachlorodibenzo-p-dioxin, regarded as the most toxic of all dioxins. In this way the final result expressed in TEQ takes into account the relative significance of each component of the mix of dioxins and furans present in the sample.

As for the PAH results, it is difficult to draw firm conclusions in terms of trends from a dataset in which samples are only taken once or twice per month. Bearing in mind the limitations of the data, there has apparently been a reduction in total TEQ over the period of record. Scatter in the data probably reflects varying exposure at the site due to changing wind direction and other meteorological factors on sampling days. For example on some days the wind may be blowing from the vicinity of an emission source, and on others from cleaner areas. Emissions sources which may influence the St Andrews site include pulp and paper mills in Maine, a wood panel manufacturing plant in St Stephen, motor vehicle emissions, woodsmoke from domestic stoves, and any other open burning in the vicinity.

Data from across Canada for dioxins and furans reveal a pattern very similar to that apparent for PAHs. Sites having relatively high levels of PAH generally have elevated levels of dioxins/furans as well. The highest values are seen in Jonquière (smelter impact), Toronto (vehicles and industrial sources) and Windsor (incinerator impact from Detroit). The lowest values are seen at Kejimkujik, NS, St Andrews, NB and Gray, SK, and are approximately ten times lower than the most heavily affected locations.

The topic of semi-volatile organic pollutants as dealt with in this measurement program is unavoidably complex. Only a basic presentation of some of the most general results is attempted in this section. Those interested in additional details or explanations should contact DELG using the contact details provided on page iii.

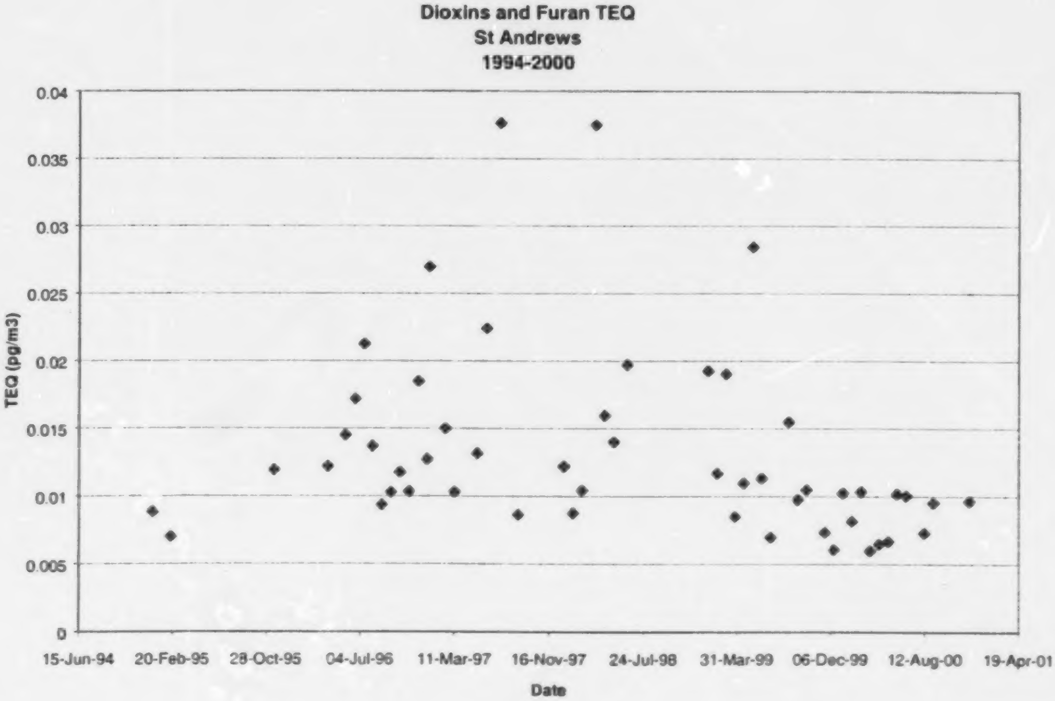


Figure 23. Dioxins and furans at St Andrews, 1994-2000.

11. RURAL OZONE NETWORK - SOUTHERN NEW BRUNSWICK

Figure 24 shows the locations of the sites which monitor ground level ozone in New Brunswick. This network is operated to assess the impact of long-range transported ozone. It focuses on the southern portion of the province, which is the region most affected by long range transport, as shown by special short-term monitoring studies and trajectory analyses (e.g. Fuentes and Dann, 1994; Tordon et al., 1994; Multistakeholder NOx/VOC Science Program, 1997a, 1997b). Two sites in the northern part of the province were added to the network in 2000, St Leonard in the northwest, and Lower Newcastle in the northeast.

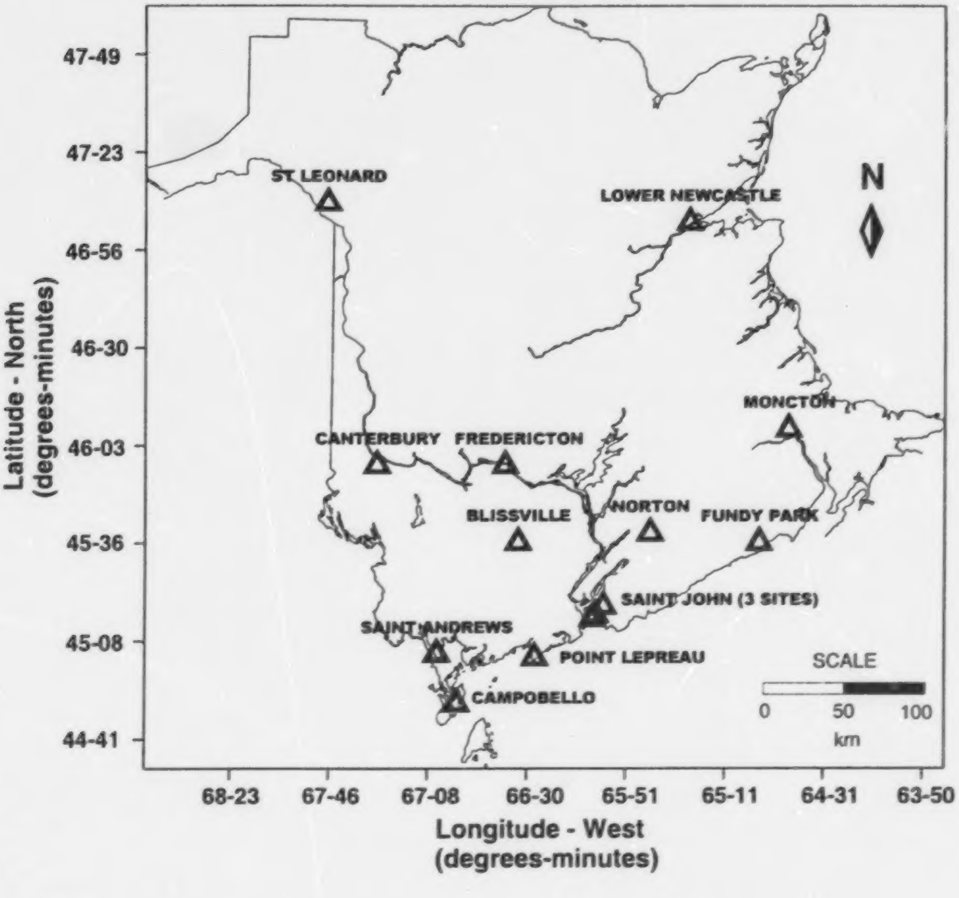

47-49
47-23
46-56
46-30
46-03
45-36
45-08
44-41
Latitude - North (degrees-minutes)
ST LEONARD
LOWER NEWCASTLE
N
MONCTON
CANTERBURY
FREDERICTON
BLISSVILLE
NORTON
FUNDY PARK
SAINT JOHN (3 SITES)
SAINT ANDREWS
POINT LEPREAU
CAMPOBELLO
SCALE
0
50
100
km
68-23
67-46
67-08
66-30
65-51
65-11
64-31
63-50
Longitude - West (degrees-minutes)

Figure 24. Locations of ozone monitoring sites in New Brunswick (2000).

Ground-level ozone readings in 2000 were low. There were only two hours exceeding the 1-h objective of 82 ppb, at the Norton site in July. The number of hours of exceedance is quite variable from year to year, being heavily influenced by the weather. Considering the Canada-Wide Standard of 65 ppb averaged over 8 hours, there was a total of 31 exceedances in the provincial network, occurring at five sites and distributed from May to August. Exceedances are summarised in the following tables.

Exceedances of the 1-hour ozone objective, 2000
(number of hours)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Customs	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest Hills	0	0	0	0	0	0	0	0	0	0	0	0	0
Hillcrest	0	0	0	0	0	0	0	0	0	0	0	0	0
Canterbury	0	0	0	0	0	0	0	0	0	0	0	0	0
Pt. Lepreau	0	0	0	0	0	0	0	0	0	0	0	0	0
St Leonard	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower Newcastle	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Andrews	0	0	0	0	0	0	0	0	0	0	0	0	0
Campobello Isl.	0	0	0	0	0	0	0	0	0	0	0	0	0
Fundy Park													N/A
Norton	0	0	0	0	0	0	**2**	0	0	0	0	0	2
Moncton	0	0	0	0	0	0	0	0	0	0	0	0	0
Fredericton	0	0	0	0	0	0	0	0	0	0	0	0	0
Blissville	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	0	0	2	0	0	0	0	0	2

The 1 hour National Objective is 82 ppb. The Campobello site is operated in summer only. Data for Fundy Park were not available due to instrument malfunction.

Exceedances of the 8-hour Canada Wide Standard for ozone, 2000 (number of hours)

Site	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Customs	0	0	0	0	0	0	0	0	0	0	0	0	0
Forest Hills	0	0	0	0	0	0	0	0	0	0	0	0	0
Hillcrest	0	0	0	0	**4**	**6**	0	**3**	0	0	0	0	13
Canterbury	0	0	0	0	0	0	0	0	0	0	0	0	0
Pt. Lepreau	0	0	0	0	0	0	0	0	0	0	0	0	0
Lower Newcastle	0	0	0	0	0	0	0	0	0	0	0	0	0
St Leonard	0	0	0	0	0	0	0	0	0	0	0	0	0
St. Andrews	0	0	0	0	0	0	**1**	0	0	0	0	0	1
Campobello Isl.	0	0	0	0	**2**	**3**	0	0	0	0	0	0	5
Fundy Park													NA
Norton	0	0	0	0	0	**2**	**6**	0	0	0	0	0	8
Moncton	0	0	0	0	0	0	0	0	0	0	0	0	0
Fredericton	0	0	0	0	0	0	**4**	0	0	0	0	0	4
Blissville	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	0	6	11	11	3	0	0	0	0	31

The Canada Wide Standard is 65 ppb averaged over 8 hours.

The frequency of ozone episodes (periods of one or more days with high readings) in New Brunswick is dependent on summer weather conditions. Ozone events typically occur when weather systems result in transport of air into the province from the south-west. A greater than normal frequency of west to north-westerly winds results in fewer days with high ozone.

Monthly means and extremes are shown in Appendix III. There is a natural seasonal cycle in ozone levels, with higher values being seen in the spring months. This is due to seasonal patterns in atmospheric circulation. This feature is apparent at most New Brunswick sites. Monthly mean values can be seen to peak in March and April.

12. ACID PRECIPITATION NETWORK

New Brunswick has operated an extensive precipitation chemistry network since the early 1980's. Since 1987, this has been a partnership effort, with logistical and financial support from NB Power. All samples are analysed at the NBDELG laboratory, and DELG staff co-ordinate the monitoring program, perform data quality assurance, and maintain the official data archive.

The potentially adverse impacts of acid precipitation have been recognised for more than 20 years. Acid rain effects are felt regionally, not just close to the sources of contaminants themselves. The emissions which cause acid precipitation (primarily sulphur dioxide and nitrogen oxides) typically travel long distances - hundreds or even thousands of kilometres - before returning to the surface in rain or snow. The same emissions also contribute to regional haze and fine particulate pollution.

Precipitation chemistry in New Brunswick is affected by the emissions from several large industrial regions which lie upwind, including the American midwest, southern Ontario and Québec, and the Washington-Boston region.

Partly because the site of impact is remote from the point of emission, no standards have been put in place for acid precipitation. Instead, the issue has been managed by the adoption of 'target' or 'critical' loads. These are similar to the objectives used in the management of other air pollutants. Although they are not legally enforceable, they do provide a goal towards which affected US States and Canadian Provinces are working, as emissions are reduced over time.

The severity of acid rain impact is generally measured by computing how much sulphate (a measure of sulphuric acid) falls on each hectare over one year. The target load for acid rain is expressed in terms of this amount of sulphate. In the late 1980's, the proposed target load for eastern Canada was 20 kilograms per hectare per year (kg/ha/yr).

This target was initially designed to provide protection to areas which are moderately sensitive to acidification. This sensitivity varies in different areas, because geological characteristics such as soils and bedrock have different abilities to neutralise the acid precipitation. This is often referred to as the 'buffering capacity'.

Over time, scientists realised that these initial target loads were not adequate to provide long term protection, or protect more sensitive watersheds. The newer concept of critical loads was introduced in the 1990's. Critical loads take into account the nature of individual watersheds, and are calculated to ensure long term protection from acidification.

Critical loads for acidification in New Brunswick range from less than 8 up to 11 kg/ha/year of sulphate input (referred to as acid sulphate deposition). The lowest values of less than 8 kg/ha/yr refer to the most sensitive areas on granite bedrock (e.g. areas of southwestern and central northern New Brunswick), and 11 kg/ha/yr to most of the rest of the Province.

In recent years, acidic deposition has been declining slowly. This means that, for the first time since monitoring began in 1980, the critical load values are beginning to be met over some parts of the Province, although still exceeded in others, notably the sensitive regions in the southwest. There is, however, still more effort required to reduce acid deposition further and ensure that the more sensitive lakes and rivers, such as those in southwestern N.B., are provided with long term protection from acid damage. Further cuts in sulphur dioxide emissions are being pursued, both in the Province and those regions of eastern Canada and the United States which are the main source regions of these acid-causing emissions.

Figure 25 shows the location of monitoring sites, and Figure 26 the acid deposition recorded in 2000. Two sites (Nictau and Penfield) did not provide complete data in 2000, due to operator changes. In northern New Brunswick deposition values in 2000 were slightly reduced compared with 1999, whereas in central and southern areas, deposition was higher by about 10% to 35%. These increases were not a result of higher precipitation, which was about 10% lower than in 1999 - they were instead due to increased sulphate concentrations in the precipitation. Overall, despite the noted increases in deposition in 2000, values were similar to those seen since 1995. Provincial sulphur dioxide emissions were about 9% higher in 2000 than 1999, but the regional deposition changes in southern New Brunswick probably reflect emission changes over a much larger upwind area, including source regions in the United States.

Acid deposition, the total amount of a chemical substance entering the environment, is a factor of both concentration in the precipitation and the amount of precipitation received. As a result, there will always be significant variability in acid deposition between years due to variability in weather patterns. Results presented in the following section on long terms trends indicate that when averaged across the province, the concentration of acidic pollutants in precipitation (which is less dependent of the amount of precipitation received) appears to be falling. Although encouraging, the data also show that the acid rain issue remains important in New Brunswick, as critical loads for acid rain are still being exceeded, especially in the south.

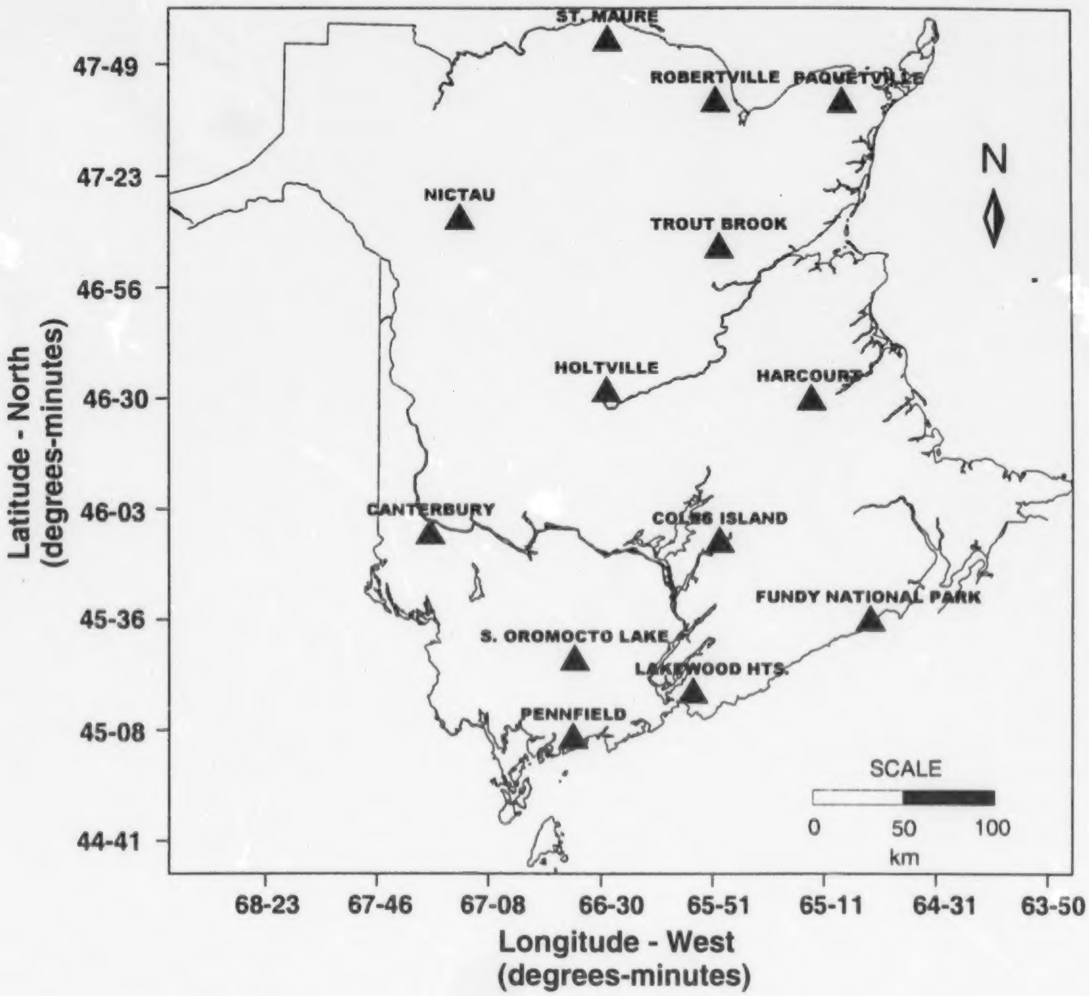

ST. MAURE
ROBERTVILLE
PAQUETVILLE
NICTAU
TROUT BROOK
HOLTVILLE
HARCOURT
CANTERBURY
COLES ISLAND
FUNDY NATIONAL PARK
S. OROMOCTO LAKE
LAKEWOOD HTS.
PENNFIELD
N
SCALE
0
50
100
km
47-49
47-23
46-56
46-30
46-03
45-36
45-08
44-41
Latitude - North
(degrees-minutes)
68-23
67-46
67-08
66-30
65-51
65-11
64-31
63-50
Longitude - West
(degrees-minutes)

Figure 25. Location of acid rain monitoring sites in New Brunswick (2000).

(Note: Nictau and Pennfield did not operate for the full year in 2000).

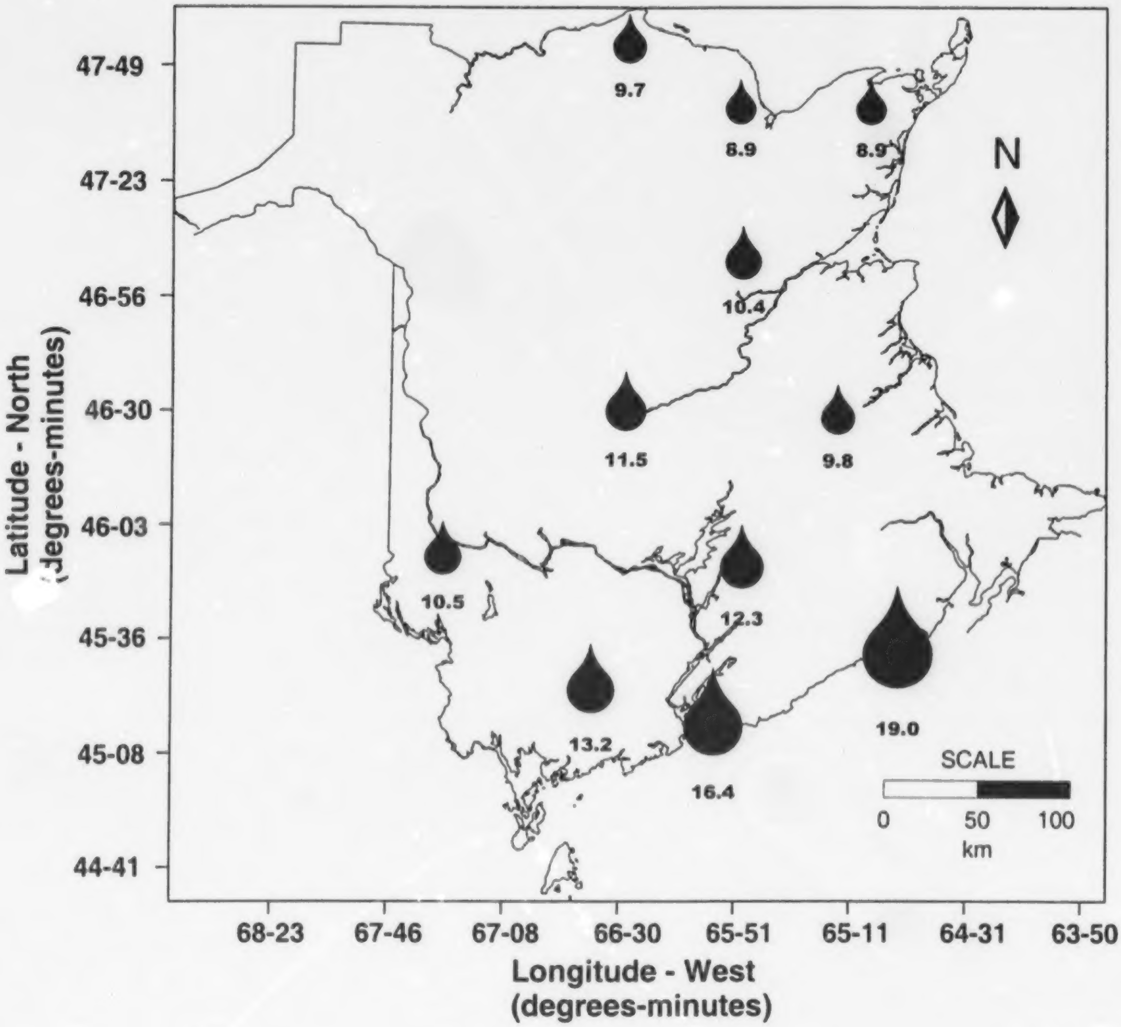

47-49
47-23
46-56
46-30
46-03
45-36
45-08
44-41
Latitude - North (degrees-minutes)
9.7
8.9
8.9
10.4
11.5
9.8
10.5
12.3
13.2
16.4
19.0
N
SCALE
0
50
100
km
68-23
67-46
67-08
66-30
65-51
65-11
64-31
63-50
Longitude - West (degrees-minutes)

Figure 26. Acid Deposition for 2000 (kilograms per hectare per year of sulphate).

The droplet symbols are sized in proportion to the deposition measured at that site. Due to site changes, only 11 sites provided complete data in 2000.

A. New England Governors/Eastern Canadian Premiers Acid Rain Action Plan

Since the early 1980's the New England Governors/Eastern Canadian Premiers (NEGECP) have met annually to discuss items of regional interest, such as trade, tourism and the environment. In the 1980's and early 1990's this collaboration led to significant efforts to address the acid rain issue, and develop emission control programs.

The NEGECP held their 2000 annual meeting in July in Halifax, Nova Scotia. Progress in 2000 included the completion of a detailed survey of public awareness, understanding and opinions about the issue of acid rain, in which people were polled across the whole northeastern region of the United States and Canada. This survey revealed that water and air quality are the top environmental concerns. Awareness and concern for acid rain varied across the region, although most people were supportive of control measures. Work progressed on a new Communications and Outreach Plan to inform the public of the activities of the NEGECP and the impacts of acidification.

A subgroup of the NEGECP worked on a project to provide real-time information on ozone in the northeastern United States and Canada, made available through the internet. The web-based maps were launched in July as an internal, working pilot project. Plans are in place to announce this system to the general public in 2001.

Two scientific reports were produced, one on the effects of nitrogen on acidification, entitled *Is Nitrogen a Serious Issue?* and the second *Model Estimation of the Effects of Sulfur Dioxide (SO2) Emissions Reductions on the Regional Aquatic Chemistry and Biology in Eastern North America,* dealing with acidification models.

As part of the effort to enhance regional monitoring, work proceeded to establish a number of USEPA samplers for fine particulate matter in the Maritime provinces. Training on these Federal Reference Method or FRM samplers took place in Maine in May for Canadian site operators. The first site in the region was set up at St Andrews, NB, in June 2000. Plans began for coordinating a network of real-time fine particle monitors across the region.

B. Canada-Wide Acid Rain Strategy for Post-2000

In October 1998, this strategy was signed by the Ministers of Environment and Energy of all provinces and territories. The Post-2000 Strategy updates efforts which have been going on since the mid 1980's to reduce emissions which contribute to acid rain. Efforts from 1985 to date have reduced sulphur dioxide emissions in eastern Canada by 50% from 1980 levels. The Post-2000 strategy contains plans to reduce acid-causing emissions even further, recognising that although progress has been made, more reductions are still needed to enable critical loads to be reached. The strategy also provides direction for other activities such as scientific monitoring and research, and it makes a formal commitment to seek further reductions in sulphur dioxide emissions from the United States.

During 2000, progress was made towards establishing new SO_2 emissions targets for the eastern provinces. This was the major focus of work under the Strategy. In support of determining new targets, a major modelling study was completed, *Emissions Scenario Simulations Using the Acid Deposition and Oxidants Model.* The results were presented at a national stakeholder meeting in Hull in July. New Brunswick held a provincial stakeholder meeting in September in Fredericton.

The national review of acid rain science and monitoring programs begun in 1999 was finalised and approved in December 2000.

Negotiations with the US on reductions of acidifying emissions continued. In December, an accord between the US and Canada (the Ozone Annex) was signed under the Canada-US Air Quality Agreement, targetting controls of NOx and VOCs. Reductions in NOx affirmed in this agreement will produce benefits in terms of acidification.

13. LONG TERM AIR POLLUTION TRENDS

In addition to examining air quality monitoring results for a given year, it is often informative and revealing to compare annual results to previous years, and consider longer term trends. This provides information on how air quality may be changing over the years, and whether emission control measures as applied to industrial operations and consumer products (notably vehicles) are influencing long term environmental quality. As mentioned in the introduction, air quality monitoring has been ongoing in parts of the province since the 1970's, especially in the Saint John region. In this section, data for key locations with long-term records are presented to provide information on air quality trends.

A. Carbon Monoxide

The only long term site for this substance is the Customs Building site in uptown Saint John. The earlier part of the record (prior to 1991) is from the nearby Post Office location. Results are predominantly influenced by motor vehicle emissions. Results show that since 1980, the annual average has changed relatively little. There are signs of a possible decrease from 1980 to the mid 1990's, and an increase since then, although the variability between years reduces the confidence that these are meaningful

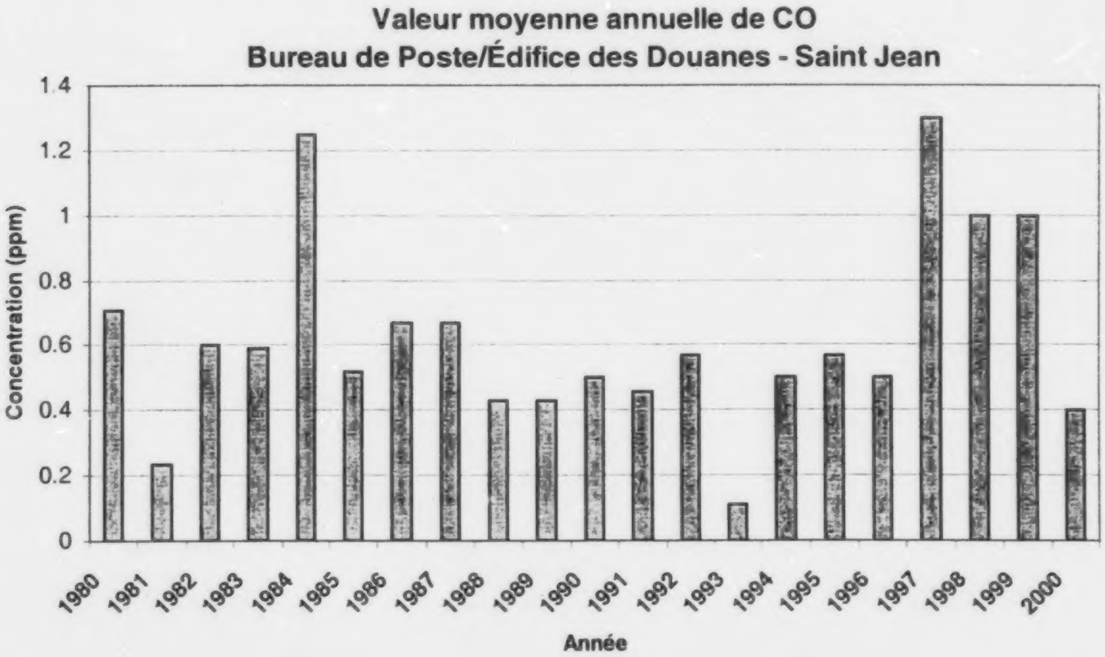


Figure 27. Annual mean values of carbon monoxide, Post Office/Customs Building, Saint John, 1980-2000.

patterns. During the period in question the population of Saint John has increased approximately 4% (Aldighieri, 1998). The number of vehicles registered and more notably, the average total kilometres driven each year, have been increasing throughout the 1990's (Goggin, 1999; Transport Canada, 1999; Statistics Canada, 1999). These pressures, which tend to increase carbon monoxide emissions, have been offset by a greater proportion of vehicles on the road fitted with emissions control equipment, such as catalytic converters. Considering the results for 2000, it appears that readings have fallen back to levels typical between the years 1985-1996.

B. Nitrogen dioxide

Forest Hills

Nitrogen dioxide is another key pollutant emitted by motor vehicles, as well as industrial sources. The trend at Forest Hills, in suburban east Saint John, appears to be downward since 1981, with little variation between years since 1987. The annual level in 2000 was the lowest since 1991. Forest Hills is influenced by emissions from local industries as well as the more diffuse sources such as vehicles.

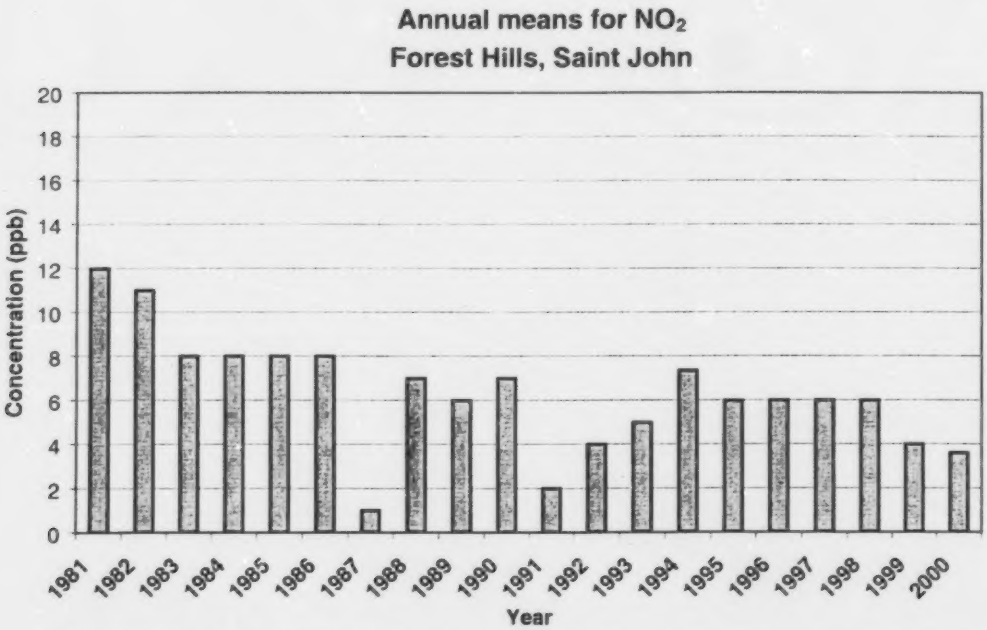


Figure 28. Annual mean nitrogen dioxide at Forest Hills, Saint John, 1981-2000.

Customs Building

Nitrogen dioxide levels appear to be stable or decreasing in recent years, following an increase from the early 1980's to 1987. In 2000, the annual mean at this uptown location was slightly higher than in 1999, but similar to most years since the early 1990's. There is no clear evidence of a progressive trend since 1992.

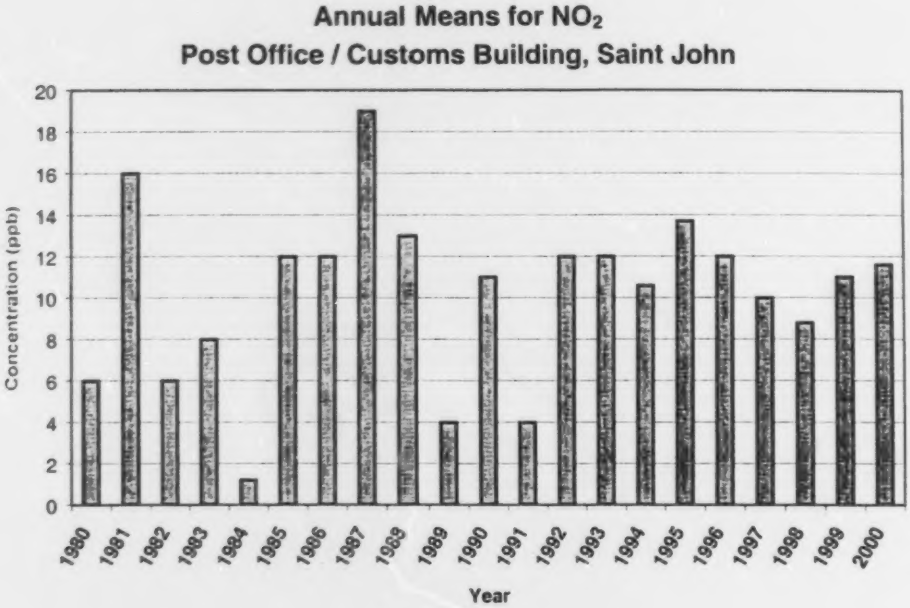


Figure 29. Annual mean nitrogen dioxide at Customs Building, Saint John, 1980-2000.

C. Sulphur dioxide

Forest Hills

Air quality monitored at the Forest Hills site in east Saint John is influenced by several local industries. Considering the trend since 1976, annual average concentrations have twice increased and decreased over the 22 year period, from 1976 to 1987 and from 1987 to 1996. In 2000, the increasing trend which was apparent from 1996 to 1999 reversed, with concentrations falling once more. Influences on sulphur dioxide levels at this site include emissions from the Courtenay Bay generating station, the pulp and paper sector, the oil refinery and possibly the Coleson Cove generating station.

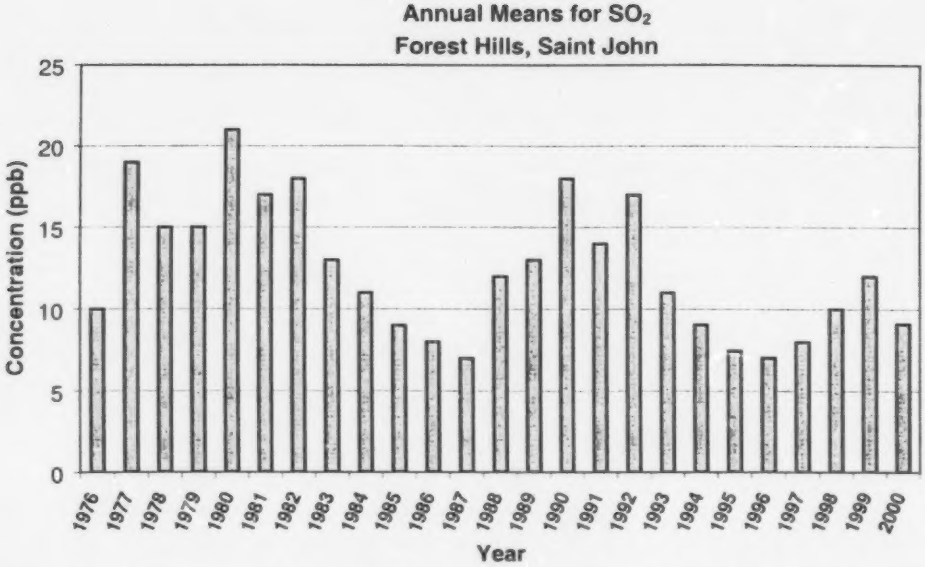


Figure 30. Annual mean sulphur dioxide at Forest Hills, Saint John, 1976-2000.

Customs Building

In uptown Saint John, as represented by records from the Post Office and Customs Building sites, the sulphur dioxide trend since the mid-1970's has been overwhelmingly downward. Recently, levels have been approximately 30% of those common in the early 1980's. Decreasing concentrations in this part of the city are probably due to reduced emissions from the Reversing Falls pulp and paper mill,

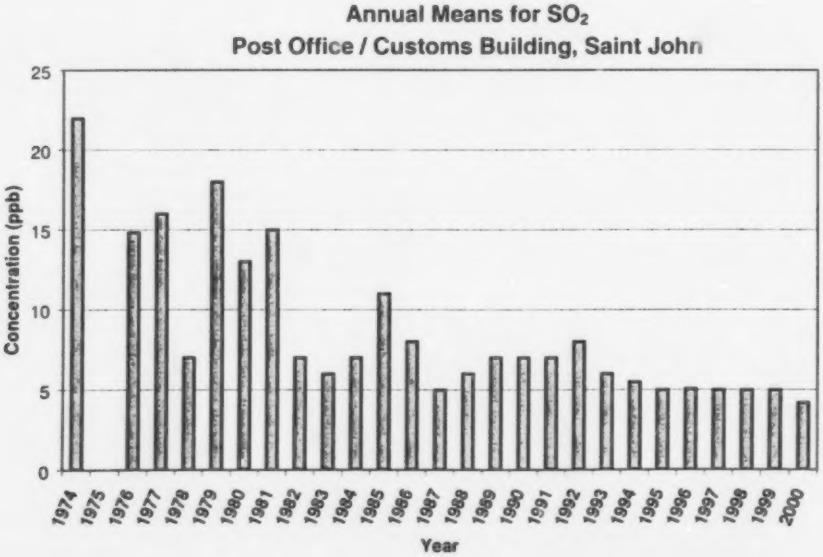


Figure 31. Annual mean sulphur dioxide at Post Office/Customs Building , Saint John, 1974-2000.

which fell by about 70% from 1980 to 1995. Reduced emissions from the NB Power Courtenay Bay generating station (down 74% from 1990 to 1995) may also be partly responsible. The annual mean in 2000 was down slightly from 1999, and was the lowest in the record so far.

D. Ozone

As explained in section 11, ozone is a regionally transported pollutant which is not emitted directly from smokestacks or tailpipes, but which forms in the air when other pollutants mix and react together. As such, trends in ozone are due to changing emissions of the pollution ingredients that are required for ozone to be made (nitrogen oxides and volatile organic compounds) over a large upwind area of eastern Canada and the United States. Seasonal weather, especially summer conditions, also has a major influence on the amount of ozone affecting New Brunswick.

Forest Hills

At Forest Hills, ozone levels have not changed significantly over the past 19 years. There have been some years such as 1984 and 1988 which had higher values, but there is no overall trend either up or down. The annual average in 2000 was the second lowest in the record.

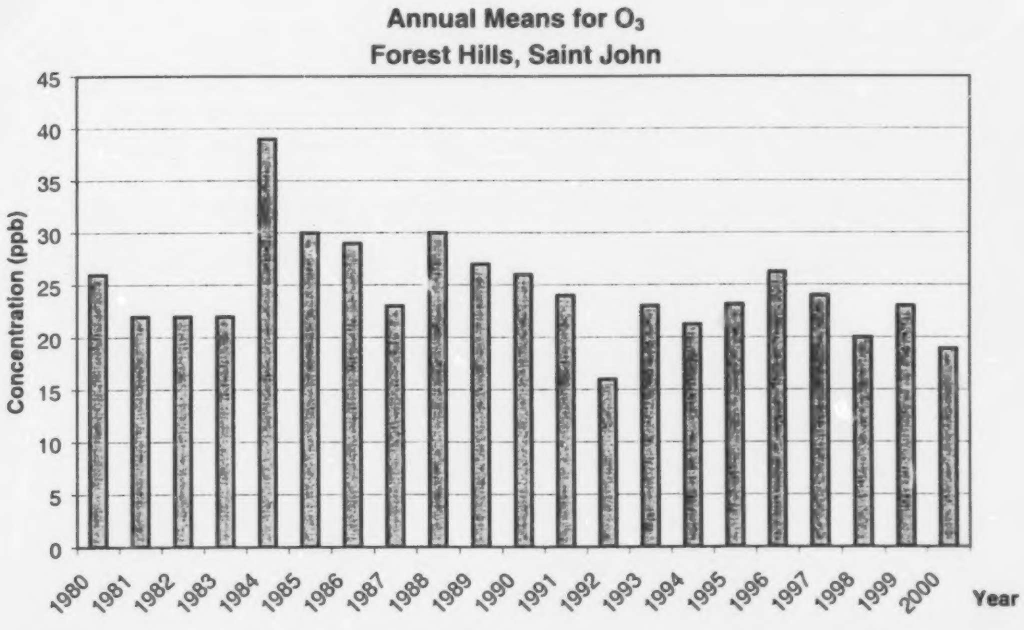


Figure 32. Annual mean ozone at Forest Hills, Saint John, 1980-2000.

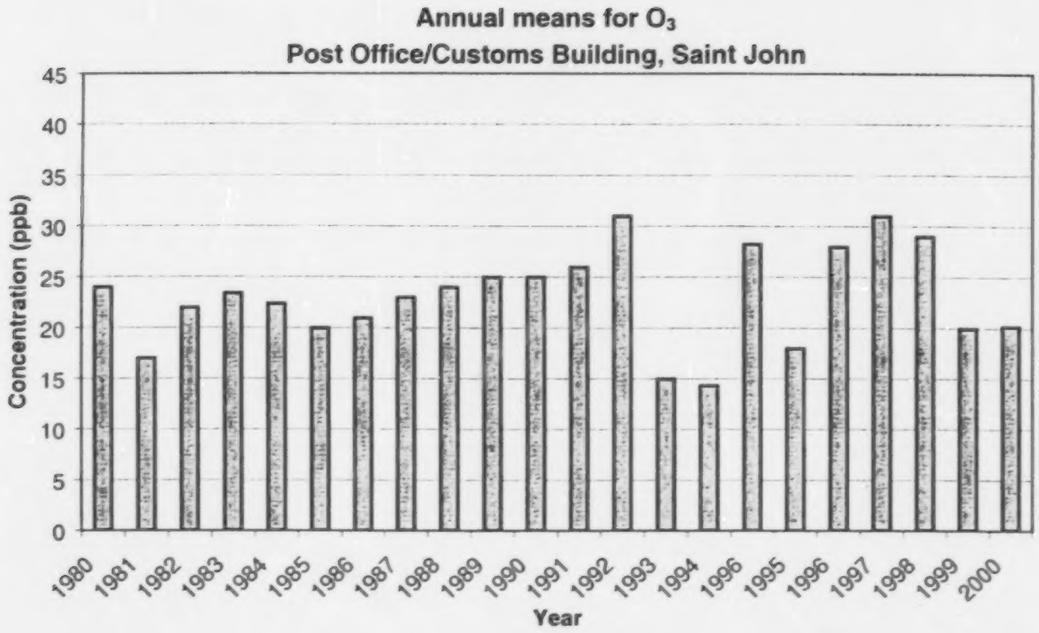


Figure 33. Annual mean ozone at Post Office/Customs Building, 1980-2000.

Customs Building

At the Customs site, annual averages for ozone have been variable since the early 1990's. Taking the most recent results into account, there is no clear trend to be seen over the period of record.

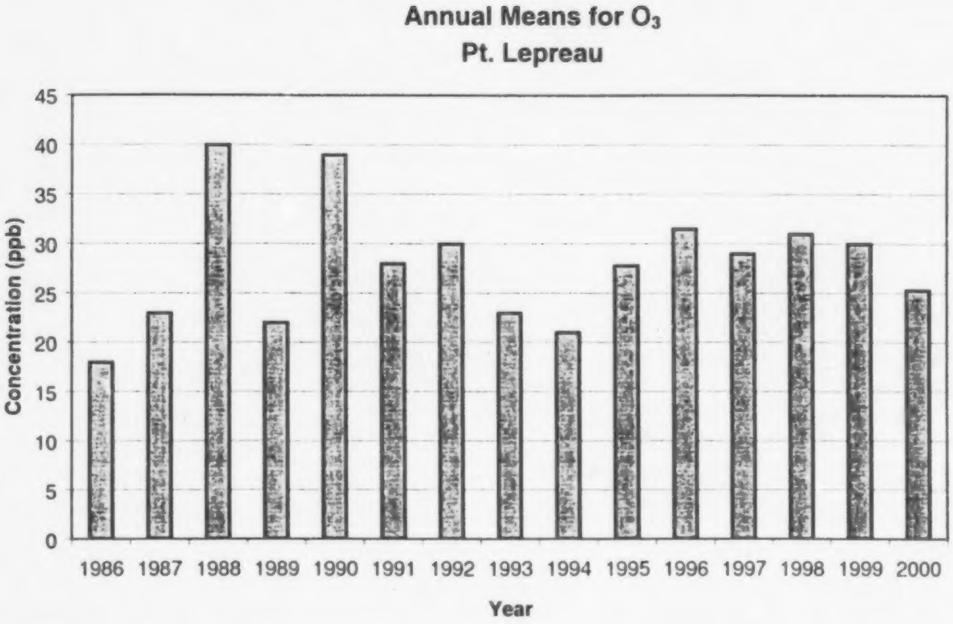


Figure 34. Annual mean ozone at Point Lepreau, 1986-2000.

Point Lepreau

Data for this site are included to provide a perspective from a rural location which is almost always upwind of major sources of air pollutants in southern New Brunswick. Annual ozone levels are somewhat higher than those seen in the Saint John area. This is due to the lack of other emissions which react with and remove ozone from the air (mainly nitric oxide).

The record at Point Lepreau reveals considerable variability between years and the indication of a possible upward trend since 1986. Although the 2000 results showed a reduction, in line with many other sites in the province, values remained broadly similar to those of the previous five years. Due to the complex relationship between ozone, its precursor compounds and weather conditions, it is very difficult to evaluate the significance of apparent trends in ozone. Within a given geographic area it is not unusual to find different trends at different sites, even though all may be apparently influenced by the same weather and pollution transport conditions. Local site factors are probably important.

E. Total Suspended Particulate

Sites which had measured TSP in Saint John ceased operation in 2000. Efforts to monitor particulate matter will in future concentrate more on the measurement of specific particulate size fractions, such as PM_{10} and $PM_{2.5}$.

Fredericton

A long term record for particulate has been maintained at the fire hall on York and Dundonald streets in Fredericton. The site is representative of most of the downtown region.

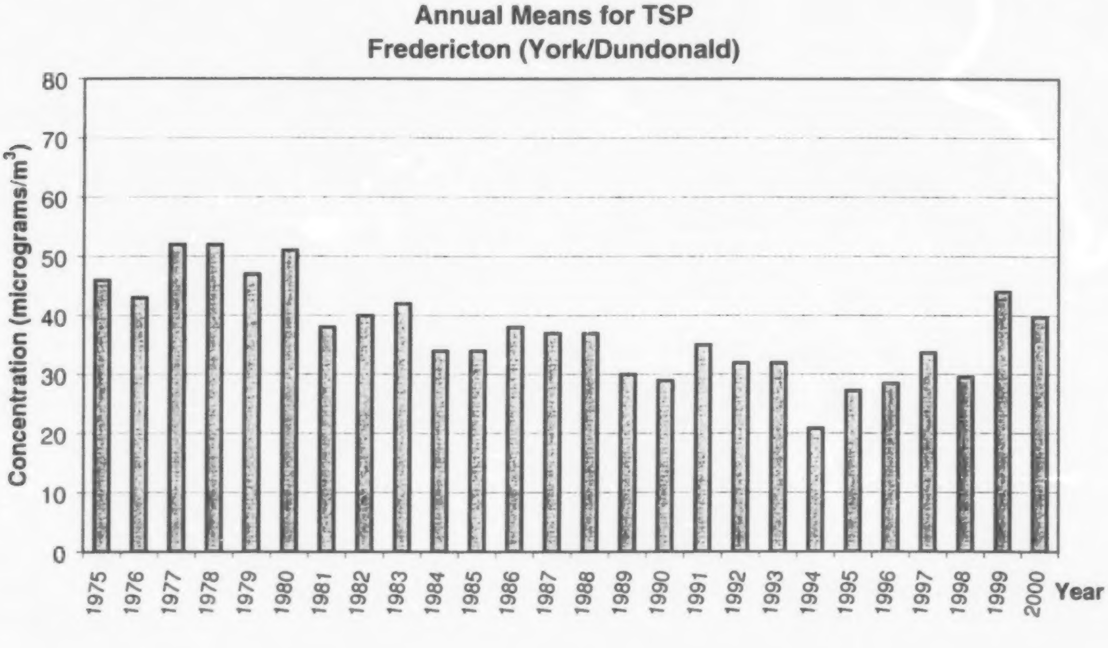


Figure 35. Annual mean total suspended particulate, Fredericton, 1975-2000.

The Fredericton data reveal a long term decreasing trend. Levels in recent years are about 50-60% of what they were in the late 1970's/early 1980's. Although elevated readings are still seen occasionally - which appear to be due to road dust and possibly also woodsmoke from domestic stoves - the overall trend is clearly downward. 2000 figures were up somewhat, inflated by a number of very high readings in the fall and winter. These high values appear to have been due to the influence of nearby construction activity.

F. Inhalable particulate (PM_{10})

Provincial Building

PM_{10} particulate matter has been measured at a small number of locations, all in Saint John, starting in 1984. The longest records are from the Provincial Building and Forest Hills sites. Data from these locations are presented here. Averaging over five years, data from the Provincial Building show a decline from 24.5 to 19.5 micrograms/cubic metre from 1984-88 to 1994-98. This decline is consistent with the decrease in total suspended particulate over the same period. The annual average in 2000 was down from 1999 and was more typical of results over the past 5-7 years.

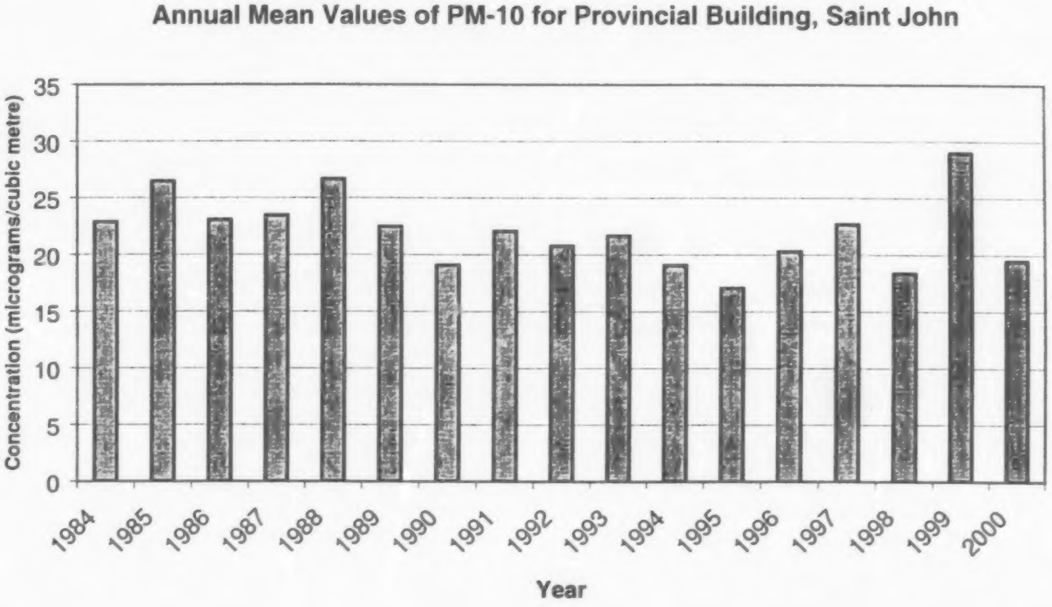


Figure 36. Annual mean PM_{10} at Provincial Building, Saint John, 1984-2000.

Forest Hills

The data from Forest Hills show a proportionally greater drop than those at the Provincial Building - almost 50% since 1989. Due to the effect of dust (especially road dust) on PM_{10}, some variation between years is to be expected, due to changes in weather (for example, the frequency of dry, windy conditions). In 2000 the annual average was down from 1999 and similar to values seen over the past five years.

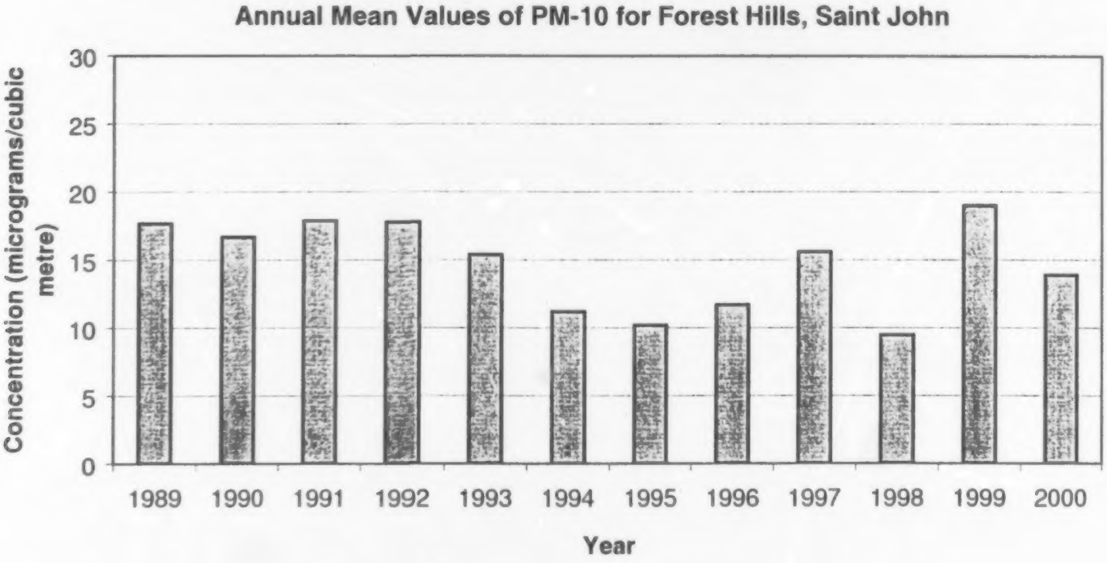
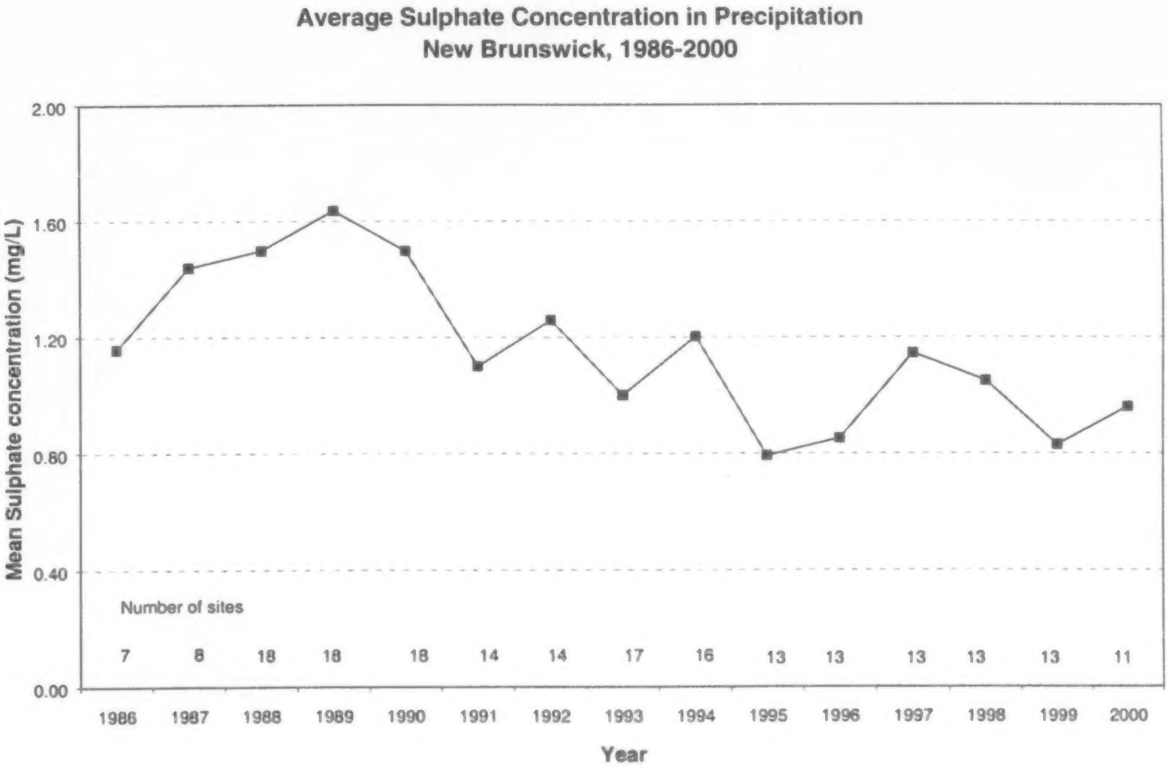


Figure 37. Annual mean PM_{10} at Forest Hills, Saint John, 1989-2000.

G. Acid Rain

Since 1986, 27 separate sites have been operated for monitoring acid deposition across New Brunswick. Provincial coverage is presently maintained with 13 sites. Due to site changes, only 11 sites provided a complete dataset in 2000.

To provide a statistic which can give some indication of long term changes or trends, the annual average sulphate concentration in precipitation was averaged across all sites operating in each year. The results are shown in the accompanying chart, which also shows the number of sites operating in each year. The apparent trend is downward since 1989. This is expected, based on reductions in sulphur dioxide emissions in eastern Canada and the United States in the same time period.



Average Sulphate Concentration in Precipitation
New Brunswick, 1986-2000

Figure 38. Network-wide mean annual sulphate concentration in precipitation in New Brunswick, 1986-2000.

H. Volatile Organic Compounds

VOCs have been measured at two locations (Forest Hills and Point Lepreau) since 1992, as noted in section 10. Routine analyses provide results for over 150 VOCs. In July 2000, sampling was begun at Champlain Heights School in east Saint John. Trends for selected VOCs are presented here.

One clear finding of the VOC sampling program is that concentrations of most VOCs are substantially higher at Forest Hills (and the new Champlain Heights location) than at Point Lepreau. This is consistent with the location of Forest Hills in an industrial urban setting and Point Lepreau in a relatively remote, rural situation.

Figure 39 shows trends in average total VOC concentrations for all sites since 1992.

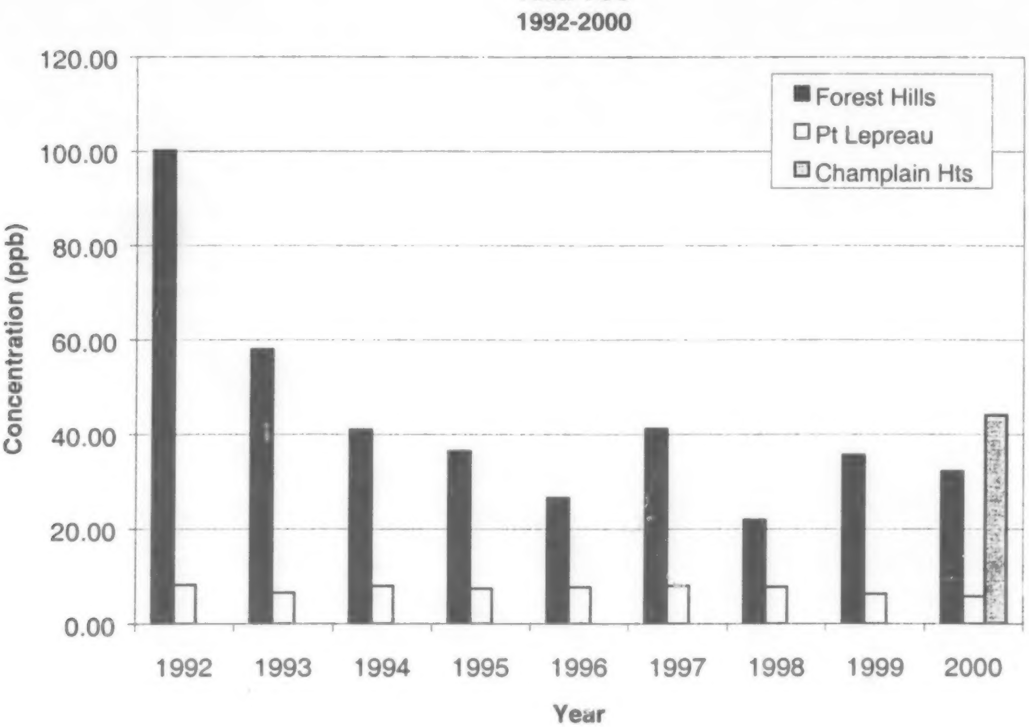


Figure 39. Average total VOC concentration at provincial VOC monitoring sites Hills, Point Lepreau, 1992-2000.

These results clearly show the difference in average VOC levels between the sites, as well as a significant downward trend in total VOC since 1992 at Forest Hills. There has been relatively little change at Point Lepreau. The decrease at Forest Hills is due to reduced levels of many individual compounds characteristic of industrial influence. Emissions from the refinery complex clearly influence the Forest Hills location, and levels of compounds such as butane and isopentane, which are major components of gasoline vapour, have shown a downward trend over the measurement period (Figure 40). Initial results from Champlain Heights show higher values than at Forest Hills. At both Point Lepreau and Forest Hills, values in 2000 were similar to those in 1999.

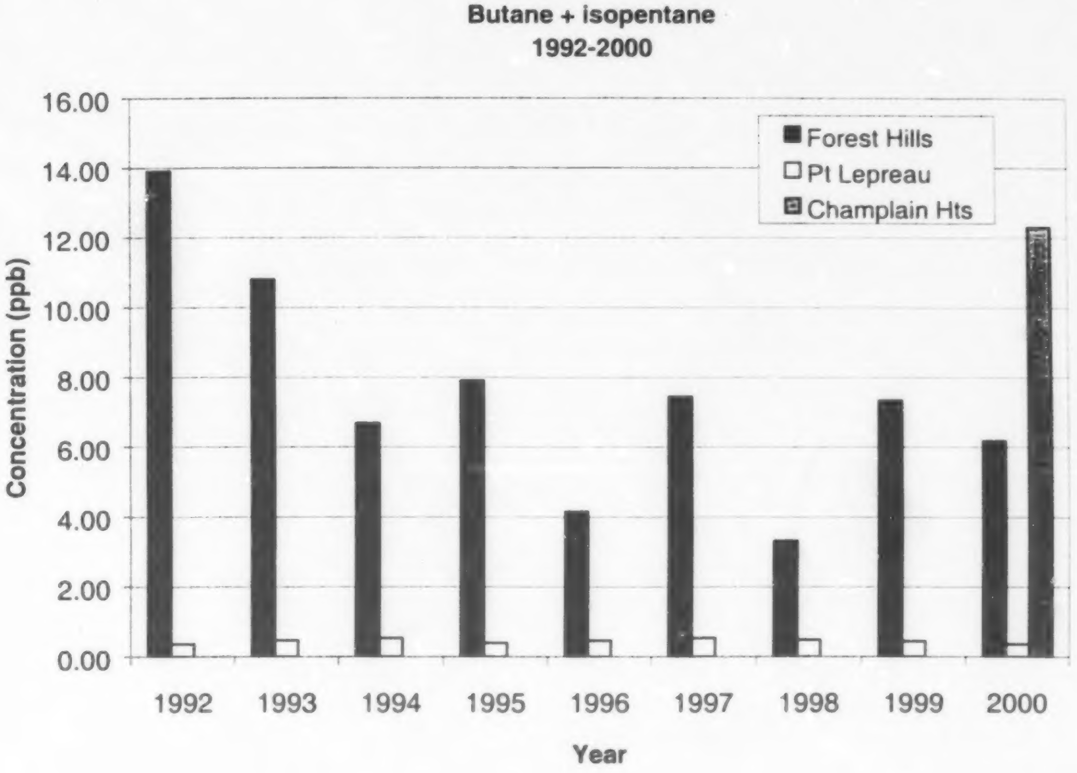


Figure 40. Annual average concentration of butane plus isopentane at Forest Hills and Point Lepreau, 1992-2000.

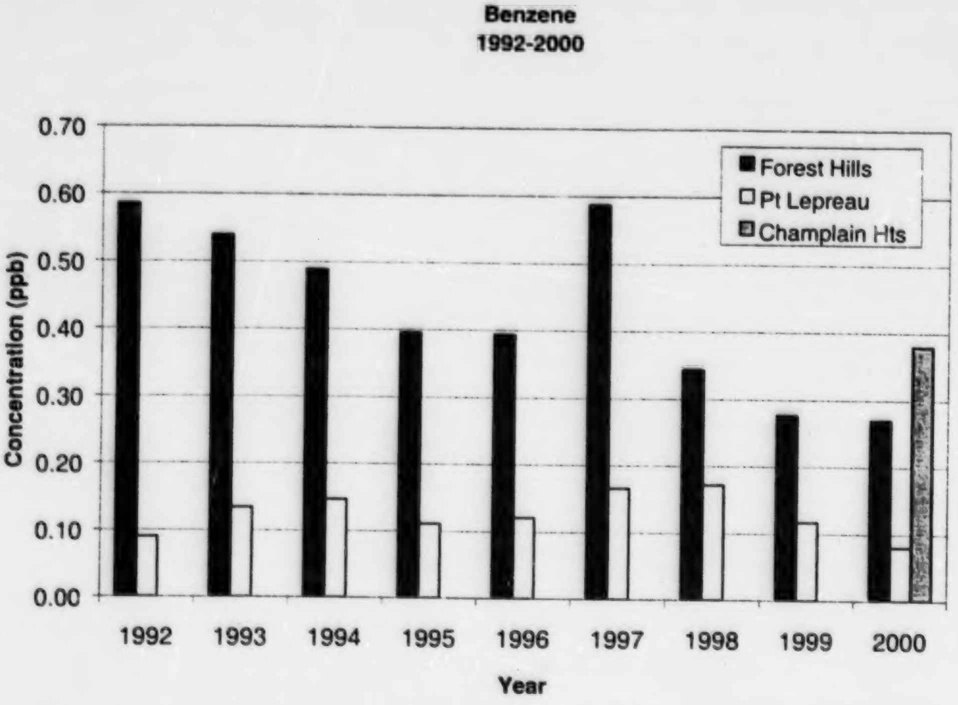


Figure 41. Annual average concentration of benzene at Forest Hills and Point Lepreau, 1992-2000.

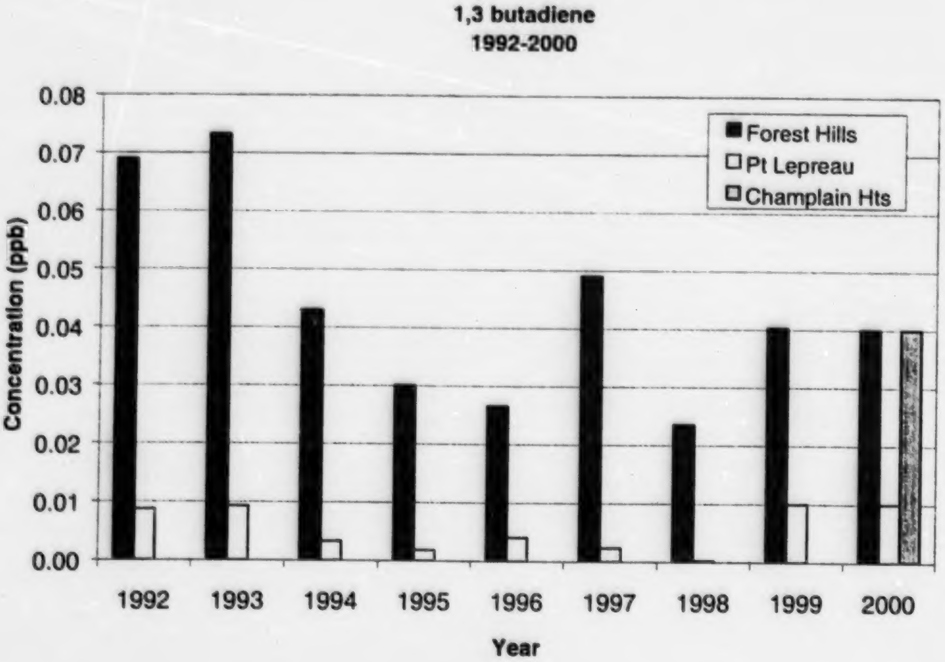


Figure 42. Annual average concentration of 1,3 butadiene at Forest Hills and Point Lepreau, 1992-2000.

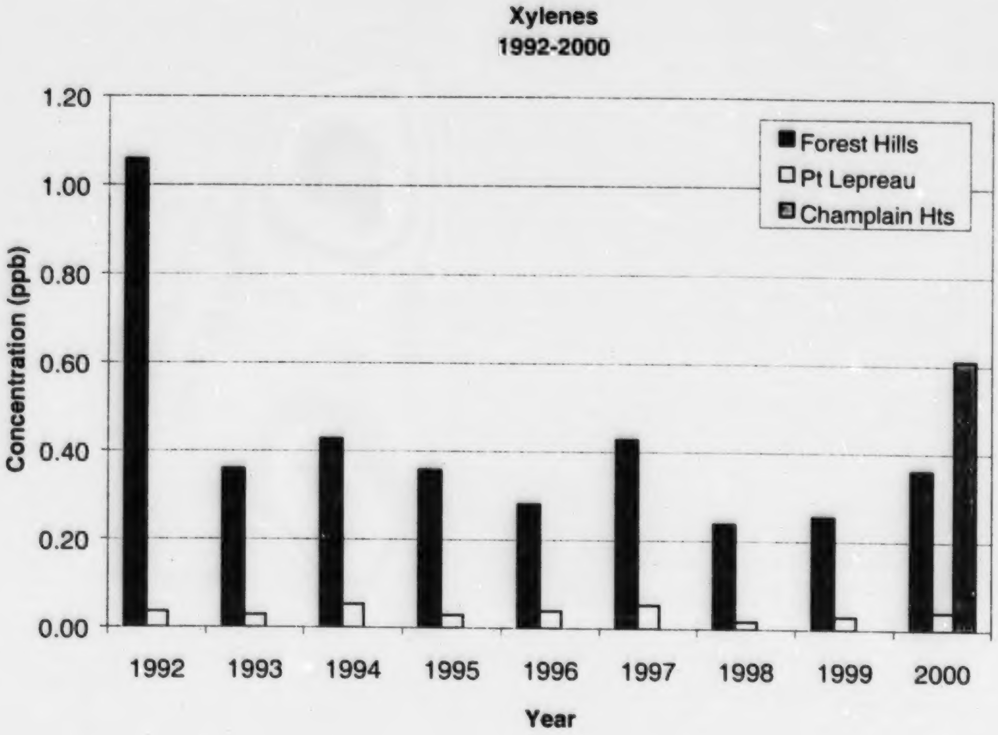


Figure 43. Annual average concentration of xylenes at Forest Hills and Point Lepreau, 1992-2000.

Some potentially toxic VOCs also show a generally decreasing trend at the Forest Hills monitoring site. Figure 41 shows the trend for benzene, Figure 42 for butadiene and Figure 43 for xylenes. In each case there is little apparent trend at the rural Lepreau site, and a decrease at the suburban Forest Hills location. Benzene is an important component of gasoline, and xylenes are associated with vehicle exhaust (Multistakeholder NOx/VOC Science Program, 1997a). Butadiene is emitted during petroleum refining and subsequent handling, as well as from internal combustion engines (e.g. CARB, 1992). The oil refinery began a leak repair program in 1995, designed to reduce VOC emissions from leaking equipment such as pumps and valves. This may have been a factor in the observed decreases of many VOCs, although the bulk of the decrease took place between 1992 and 1995. Other changes may have had some influence, such as an increasing proportion of vehicles on the road being equipped with emission control devices.

APPENDIX I: GLOSSARY OF TERMS AND ABBREVIATIONS

micrograms/m^3	Microgram (of contaminant) per cubic metre (of air).
Two-way catalytic converter	A device fitted to motor vehicle exhaust systems which reduces their output of air pollutants. A 2-way converter is designed to reduce the carbon monoxide and hydrocarbon emissions. Fitted to new light duty motor vehicles sold in Canada after 1974.
Three-way catalytic converter	A 3-way converter reduces nitrogen oxides (NOx) from motor vehicle exhaust, in addition to the pollutants removed by a 2-way catalytic converter. Fitted to new light duty motor vehicles sold in Canada after 1987.
Acidic deposition	The input of acidic pollutants to the environment, usually expressed as kilograms per hectare per year of acid-forming substances such as sulphates and nitrates (see acid rain).
Acid rain	A term which refers to rain (and snow) which has become abnormally acidic due to the effects of acidifying gases such as sulphur dioxide and nitrogen dioxide.
Acid aerosols	Very small (usually invisible) airborne particles which contain acids.
Acidification	The process by which lakes, rivers or whole drainage basins can be adversely affected by continued inputs of acid rain.
Act	A broad piece of legislation which provides authority to government departments and Ministers to develop more specific regulations and policies, and carry out related enforcement activities.
Aerosol	When referring to air pollution, aerosol means small suspended particles in the air, which may be natural or resulting from human activities.
Air quality Index	A near real-time information system providing the public with an indication of overall air quality, expressed as a single number (usually on a 0-100 scale). The index takes into account measurements of several pollutants.

Ambient air	Outdoor air.
Approval to Operate	A permit issued to businesses which tells them what they must do to comply with environmental protection requirements. For example these permits specify allowable emissions of various substances, how often reports must be made to the NBDELG, what these reports must contain, and mandatory annual testing.
ARMA committee	Air Resource Management Area Committee. Several such committees have been formed in New Brunswick since 1994, to examine local air quality issues and submit recommendations to the Minister of the Environment and Local Government.
Asthma	A disorder of the respiratory system, associated with difficulty in breathing.
Bronchitis	Inflammation of the small bronchial tubes in the lungs, which may be associated with breathing difficulties, discomfort or coughing.
Carbon monoxide	Abbreviation: CO. A colourless, odourless, toxic gas formed when fuels burn inefficiently.
CO	Carbon monoxide.
Cardiovascular	Having to do with the heart and blood circulation system.
Catalytic converter	In a motor vehicle, a device for converting harmful exhaust gases into less harmful substances. These converters use a chemical catalyst which causes the chemical conversion to take place. See 2- and 3-way catalytic converter.
Certificate of Approval	See Approval to Operate.
Clean Air Strategy	A policy document of the NBDELG, published in 1993, reviewing air quality in New Brunswick and setting out directions for future efforts to improve it.
Corridor	In air pollution terminology, refers to a region through which prevailing winds frequently pass, carrying air pollutants. For example the Windsor-Quebec City corridor, the Washington-Boston corridor.

Critical load	Referring to acid rain, the amount of acid input a region can receive which results in no long term adverse affects to at least 95% of its lakes.
Emphysema	A condition in which the air sacs in the lungs are abnormally enlarged, causing lack of breath.
Episode control program	An agreed-upon system of actions to be taken by an industry or other source or air contaminants, designed to prevent the occurrence of exceedances.
Exceedance	When referring to air pollution, an occasion on which a specified air quality standard or objective was surpassed. Note that hourly exceedances refer to measurements made over standard clock hours.
Geometric mean	A way of calculating a meaningful average from data which contains extreme values.
Ground level ozone	Ozone found in the air in the lower atmosphere, including the air we breathe. See ozone.
Guideline	A recommended value, but one which usually does not have the force of law. See objective.
H_2S	Hydrogen sulphide.
Hydrocarbon	A compound containing only hydrogen and carbon. For example methane, propane and butane are all hydrocarbons.
Hydrogen sulphide	Abbreviation: H_2S. A toxic gas, smelling powerfully of rotten eggs, detectable by the human nose at very low concentrations. Formed by some paper making processes and also found in sewer gases and naturally in swamps and marshes, where it is produced by decomposing plants.
Inhalable particles	Particles of soot, dust etc., which are small enough that they may enter the lungs without being filtered out by the nose and throat.
IQUA	Index of the Quality of the Air. A system used in Saint John since 1979 to provide the public with a reference indicator for air quality. See Air Quality Index.

kg	Kilogram.
Long range transport	In air pollution terminology, refers to the movement of air pollutants by prevailing winds and weather systems hundreds or thousands of kilometres from where they are released.
Microgram	A millionth of a gram.
Modelling	In the context of air pollution, this terms refers to computer modelling: using simulations of the atmosphere and other natural processes to explore the probable outcome of changing pollution emissions, or the impact of other factors such as weather on pollution levels.
NAAQO	National Ambient Air Quality Objective. Nationally recommended guideline concentrations for air contaminants, designed to provide protection of human health and the environment generally.
Nanogram	A thousand-millionth of a gram or 10^{-9} grams.
NBDELG	The New Brunswick Department of the Environment and Local Government.
Nitrogen oxides	Compounds of nitrogen and oxygen, primarily referring to nitric oxide and nitrogen dioxide. Abbreviation: NOx.
NOx	See nitrogen oxides.
NO_2	Nitrogen dioxide.
Objective	In the context of air quality, a management goal for environmental protection, usually stated as a number (see the definition for guideline). Objectives may also be broader in nature and expressed as plain language statements. Objectives do not normally have legal force.
Ozone	Abbreviation: O_3. A colourless gas, formed from three oxygen atoms, having a sharp odour at high concentrations. Ozone is very chemically active and can damage living plant and animal cells. Ozone is a major component of photochemical smog, and is formed in this situation by reactions between other air pollutants.
O_3	Ozone

Particulate	A very small piece of soot, smoke or dust; by inference, one which is small enough to become airborne.
Percentile	A statistical term used to classify data according to the frequency of occurrence of a given result. For example, the 50th percentile of a dataset is equal to the mean, or average value. The 75th percentile value is the value which is equal to or greater than 75% of all the measurements contained in that dataset.
Photochemical smog	A mixture of air pollutants usually containing ozone, nitrogen oxides, and particulates. Seen over or downwind of major city areas, typically in hot, sunny weather together with light winds. Often visible against a clear sky as a whitish, yellow or brown cloud or layer.
Picogram	One million-millionth of a gram, or 10^{-12} grams.
ppb	Parts (of contaminant) per billion (parts of air).
ppm	Parts (of contaminant) per million (parts of air).
pphm	Parts (of contaminant) per hundred million (parts of air).
PM_{10}	Particulate matter where the individual particles have an effective diameter of 10 microns (millionths of a metre) or less. These particles are small enough to be bypass filtration by the nose and may enter the lungs.
$PM_{2.5}$	Particulate matter where the individual particles have an effective diameter of 2.5 microns (millionths of a metre) or less. These particles may be deposited in the lungs if inhaled.
Radiation balance	The process by which the earth remains at a more or less constant temperature, by radiating as much heat into space as it receives from the sun. So-called greenhouse gases (such as carbon dioxide or methane) affect this balance by slowing down the loss of heat from the lower atmosphere.
Regulation	A formal legal document, made with the authority of an Act, which specifies rules in more technical detail than is given in the Act itself.

Smog advisory	A public information message providing details of expected ground level ozone pollution in the following 24 hours. A smog advisory program has operated in New Brunswick since 1993.
Smog	Originally, a mixture of smoke and fog. Now more often used to refer to pollution mixtures containing ozone and fine particles. See photochemical smog.
SO_2	Sulphur dioxide.
Standard	A numeric value used for the purpose of environmental management: usually refers to an acceptable concentration of a contaminant. Differs from a guideline, goal or objective by having legal force.
Sulphur dioxide	A gas generated when sulphur-containing fuels are burned, having a characteristic, acrid smell. One of the most widespread air pollutants around the world, associated with heavy industry (e.g. smelting, oil refining and major fuel combustion in generating stations).
Target load	Referring to the issue of acid deposition, an interim goal for environmental protection.
TEOM	A type of continuous measuring device for monitoring the particulate content of ambient air. Refers to the measurement principle (Tapered Element Oscillating Microbalance).
TSP	Total suspended particulate.
Total suspended particulate	Abbreviation: TSP. A standard measure of particle concentration in the air. Includes smoke, soot, pollen and other dust from about 0.1 up to approx. 50 microns in diameter.
Trajectory analysis	A method for following the movement of air over long distances, enabling the probable source regions of pollutants to be identified.
VOC	Abbreviation for volatile organic compound. Includes carbon-containing substances which evaporate readily at normal environmental temperatures, examples include gasoline, the solvents in paint, nail polish remover, and many natural VOCs.

APPENDIX II: CANADIAN NATIONAL AIR QUALITY OBJECTIVES

Canadian National Air Quality Objectives

		Sulphur Dioxide	TSP	Carbon Monoxide	Ozone	Nitrogen Dioxide	Hydrogen Sulphide
		ppb	$\mu g/m^3$	ppm	ppb	ppb	ppb
Maximum Tolerable Level[1]	1 h				153	532	
	8 h			17.5			
	24 h	306	400			160	
	1 yr.						
Maximum Acceptable Level[2]	1 h	344		30.6	82	213	10.8
	8 h			13.1			
	24 h	115	120		25	106	3.6
	1 yr.	23	70		15	53	
Maximum Desirable Level[3]	1 h	172		13.1	51		0.7
	8 h			5.2			
	24 h	57			15		
	1 yr.	11	60			0.03	

Notes: 1. The maximum tolerable level denotes a concentration of an air pollutant that requires abatement without delay to avoid further deterioration to air quality that poses a substantial risk to public health.

2. The acceptable level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well being.

3. The desirable level defines the long-term goal for air quality and provides the basis for an anti-degradation policy for the unpolluted parts of the country.

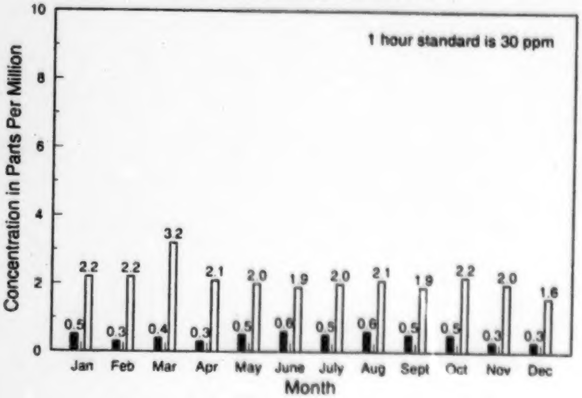
TSP : Total suspended particulate.

$\mu g/m^3$: Micrograms per cubic metre.

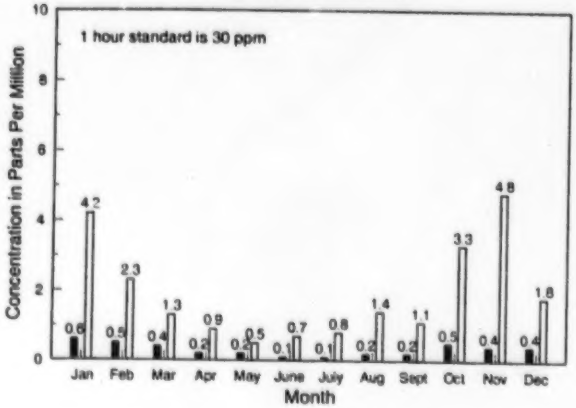
APPENDIX III

DETAILED MONTHLY MONITORING RESULTS FOR 2000

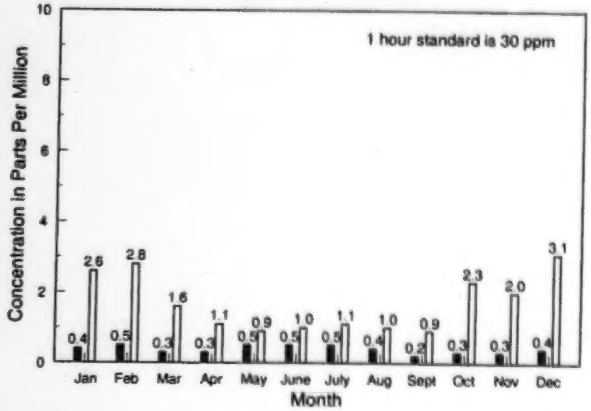
Monthly Average & Maximum One Hour Values of Carbon Monoxide in 2000
Customs Building - Saint John



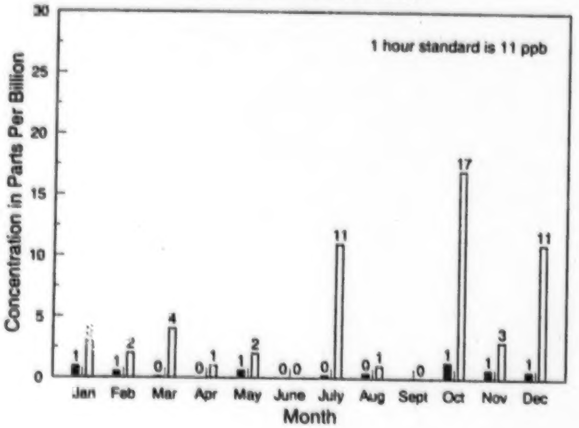
Monthly Average & Maximum One Hour Values of Carbon Monoxide in 2000
Highfield St. - Moncton



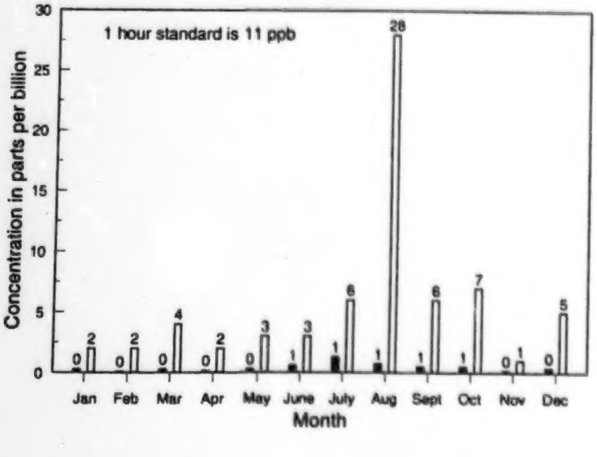
Monthly Average & Maximum One Hour Values of Carbon Monoxide in 2000
Aberdeen St. - Fredericton



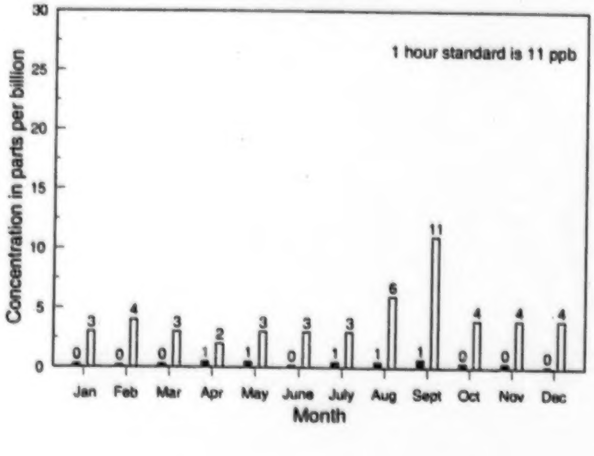
Monthly Average & Maximum One Hour Values of Hydrogen Sulphide in 2000
West Side Station (Hillcrest)



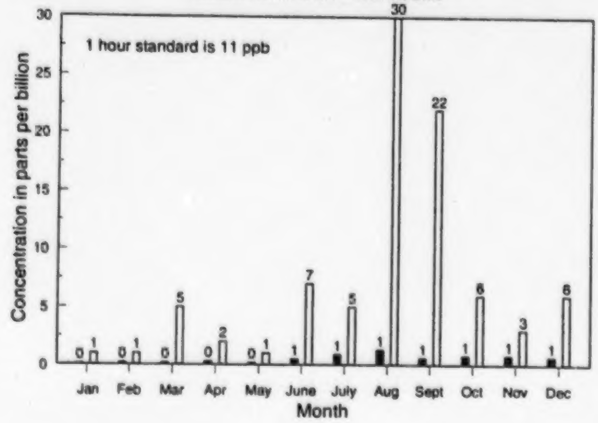
Monthly Average & Maximum One Hour Values of Total Reduced Sulphur in 2000
Indian Town - Saint John



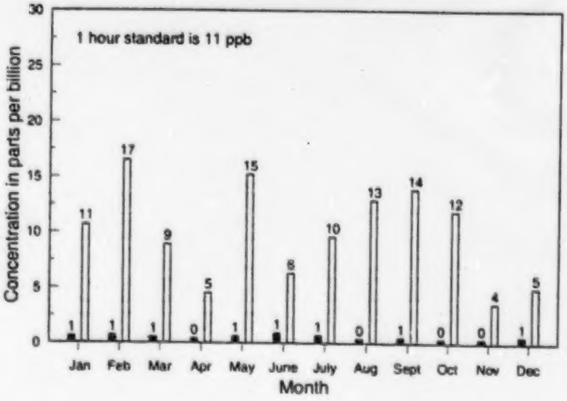
Monthly Average & Maximum One Hour Values of Total Reduced Sulphur in 2000
Milford - Saint John



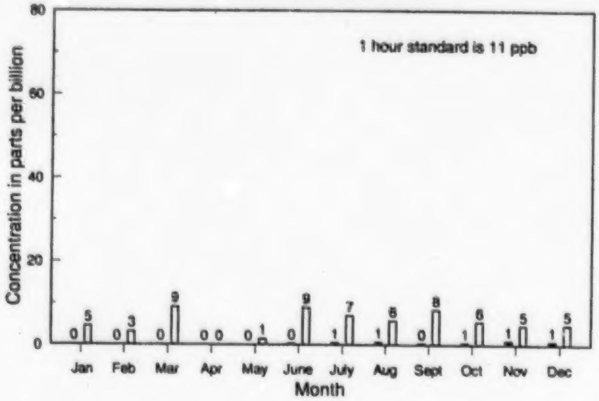
Monthly Average & Maximum One Hour Values of Total Reduced Sulphur in 2000
Sherbrooke Street - Saint John



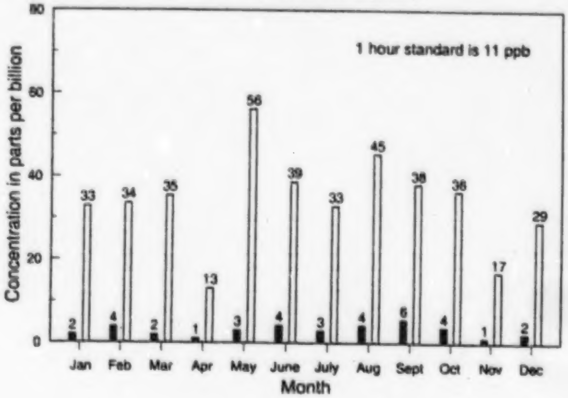
Monthly Average & Maximum One Hour Values of Total Reduced Sulphur in 2000
Ste. Anne-Nackawic



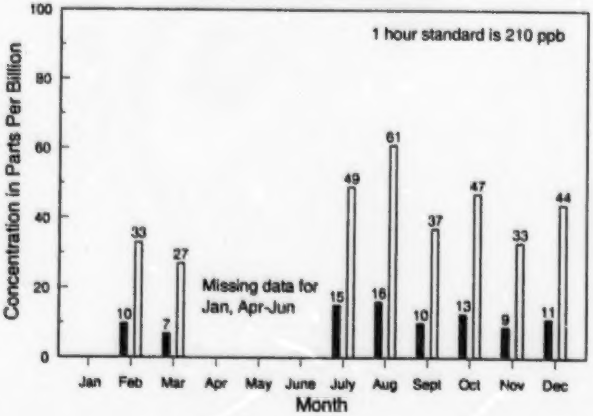
Monthly Average & Maximum One Hour Values of Total Reduced Sulphur in 2000
REPAP - Groundwood Mill



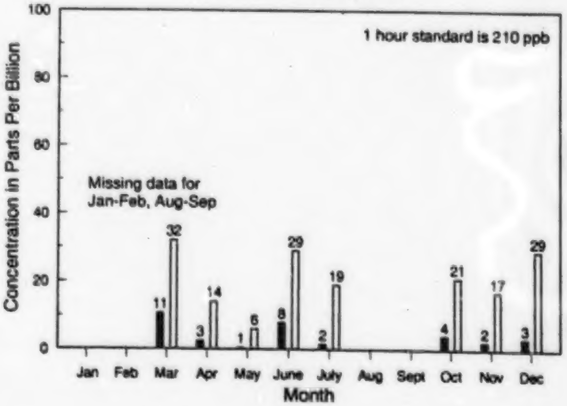
Monthly Average & Maximum One Hour Values of Total Reduced Sulphur in 2000
REPAP - King George Highway



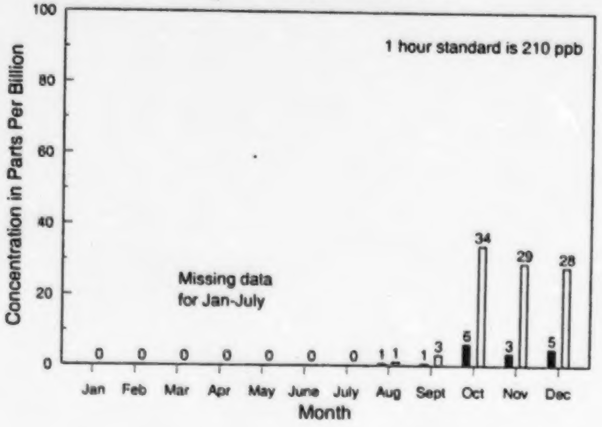
Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
Customs Building - Saint John



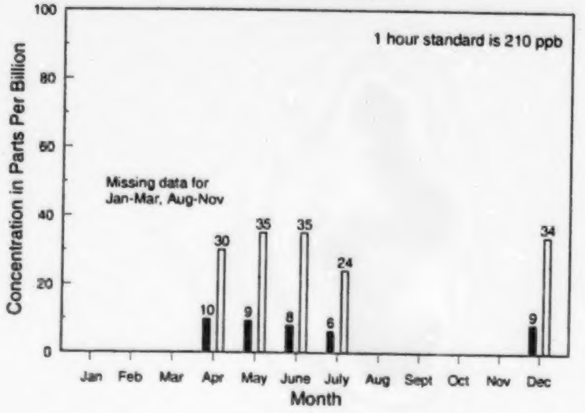
Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
Forest Hills - Saint John



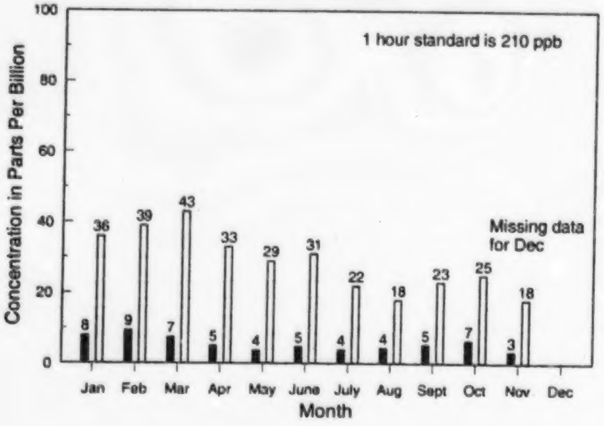
Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
Champlain Heights - Saint John



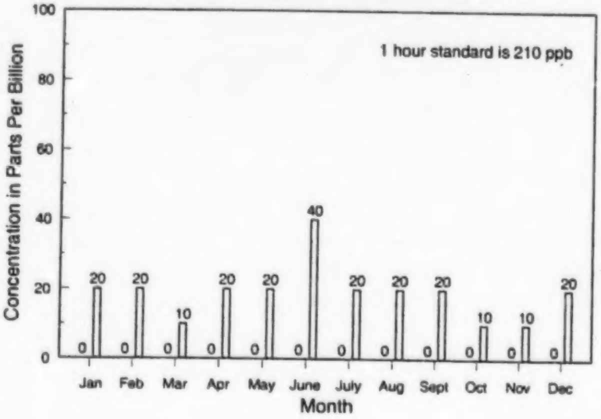
Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
Highfield St. - Moncton



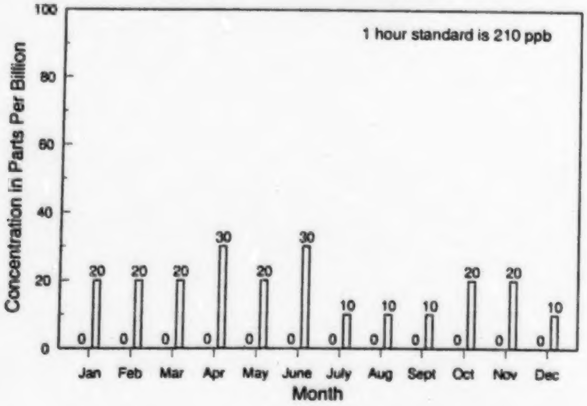
Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
Aberdeen St. - Fredericton



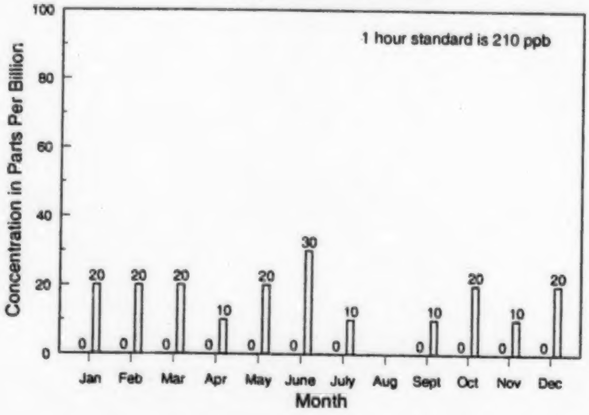
Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
NB Power Belledune - Belledune East



Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
NB Power Belledune - Municipal Hall

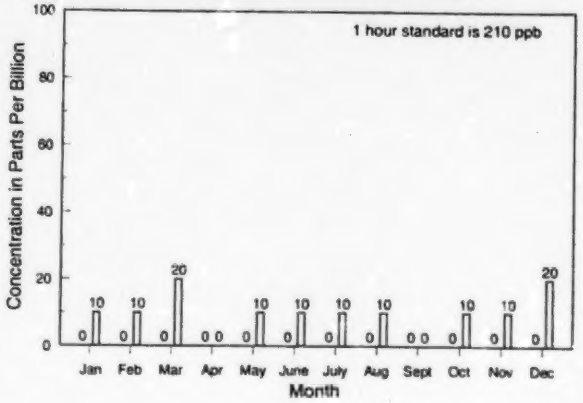


Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000
NB Power Millbank - Rockcliff



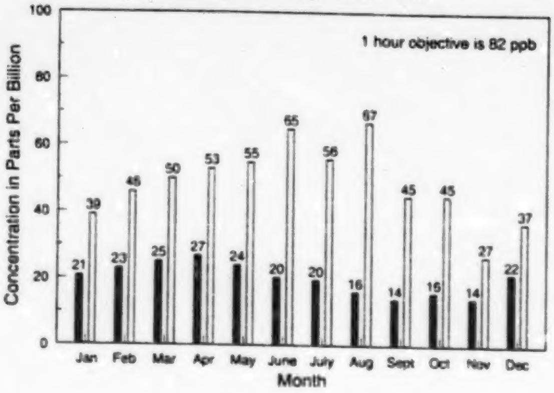
Monthly Average & Maximum One Hour Values of Nitrogen Dioxide in 2000

NB Power Millbank - Lower Newcastle



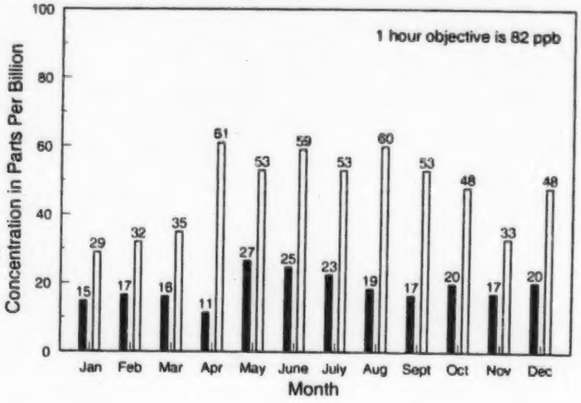
Monthly Average and Maximum One Hour Values of Ozone in 2000

Customs Building - Saint John



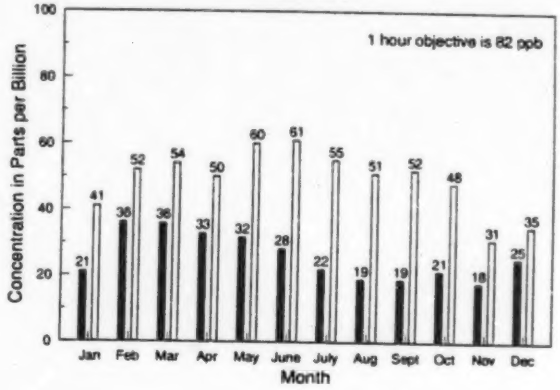
Monthly Average & Maximum One Hour Values of Ozone in 2000

Forest Hills - Saint John



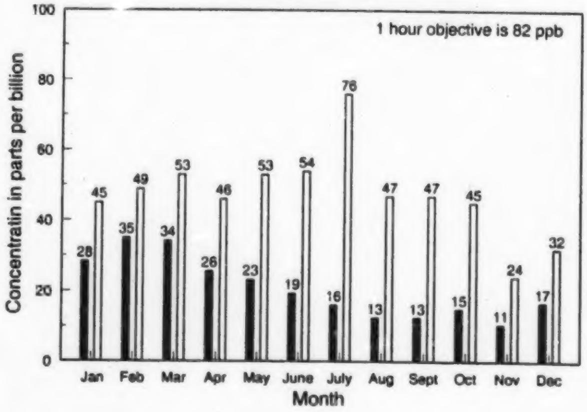
Monthly Average & Maximum One Hour Values of Ozone in 2000

Canterbury



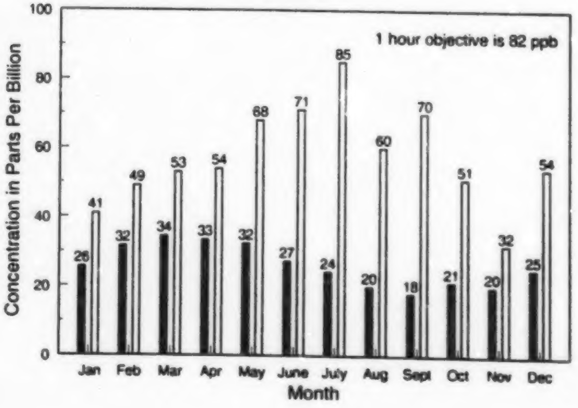
Monthly Average & Maximum One Hour Values of Ozone in 2000

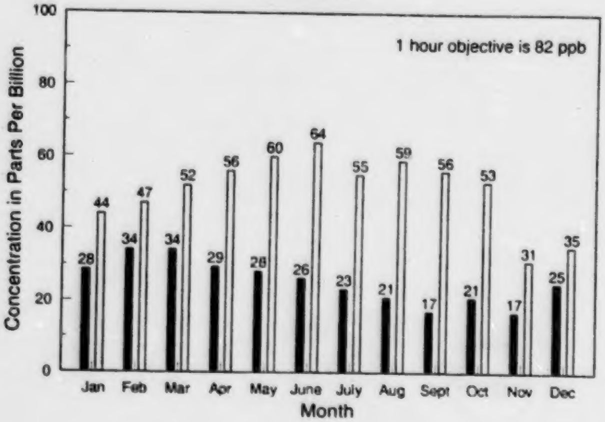
Central Blissville

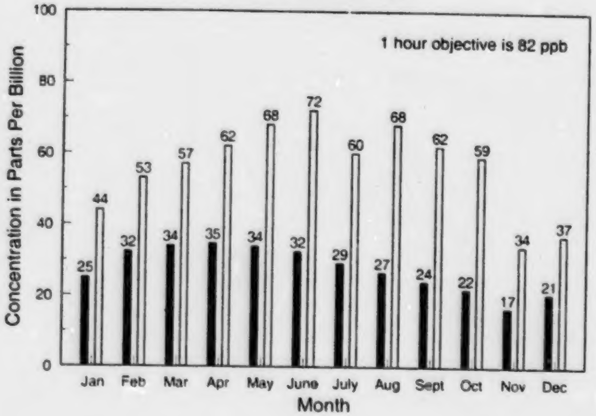


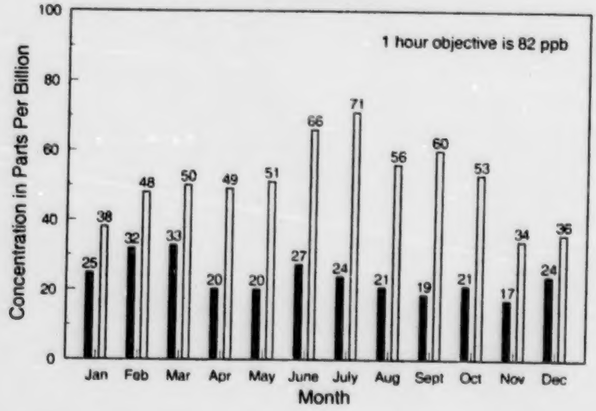
Monthly Average & Maximum One Hour Values of Ozone in 2000

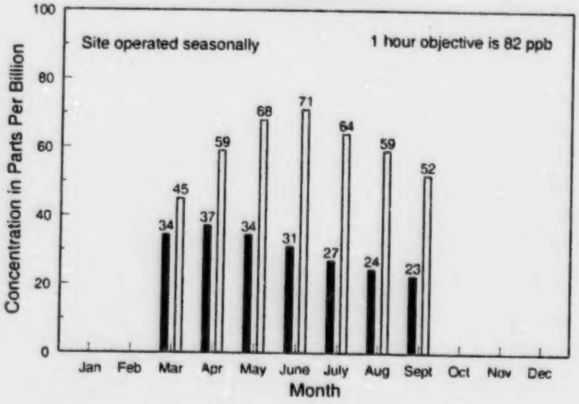
Norton




Monthly Average & Maximum One Hour Values of Ozone in 2000
Pt. Lepreau


Monthly Average & Maximum One Hour Values of Ozone in 2000
Hillcrest -Saint John


Monthly Average & Maximum One Hour Values of Ozone in 2000
St Andrews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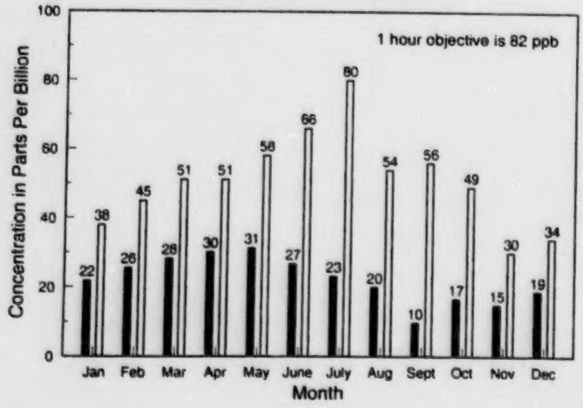
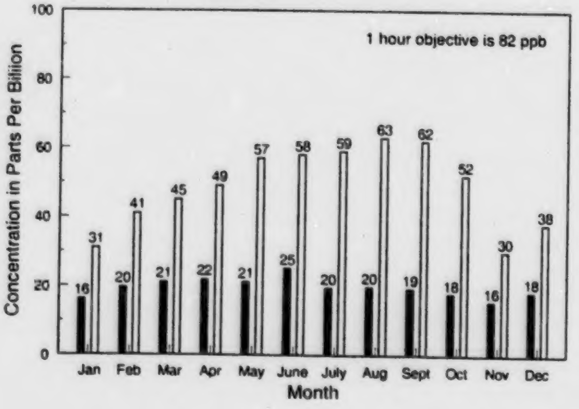
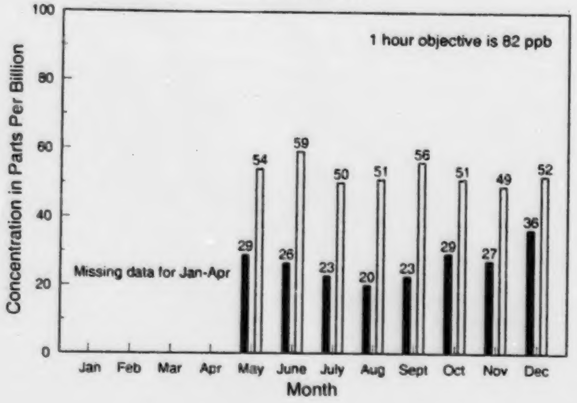
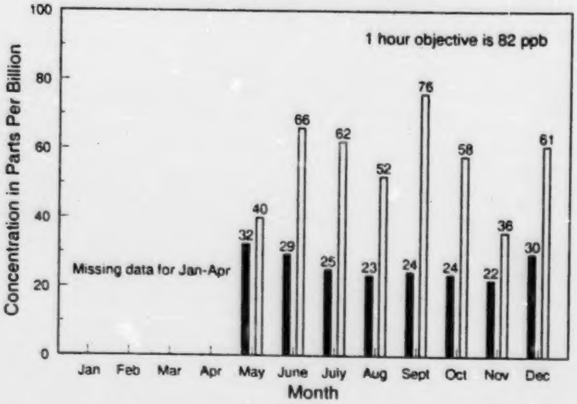

Monthly Average & Maximum One Hour Values of Ozone in 2000
Aberdeen St - Fredericton


Monthly Average & Maximum One Hour Values of Ozone in 2000
Highfield St - Moncton

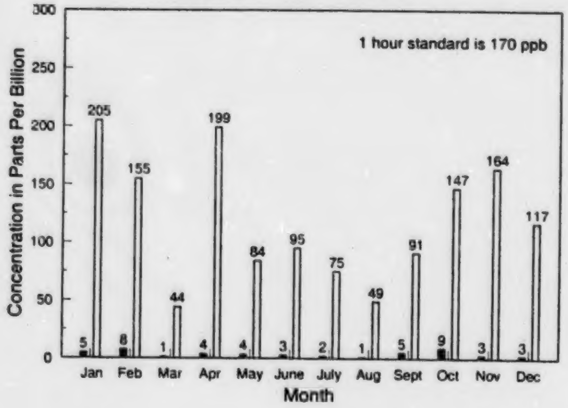
Monthly Average & Maximum One Hour Values of Ozone in 2000
St Leonard



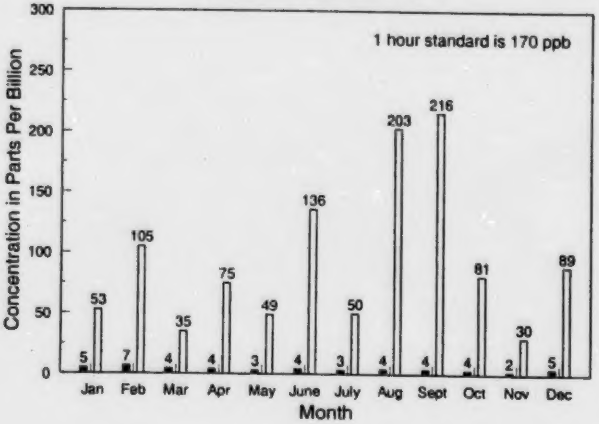
Monthly Average & Maximum One Hour Values of Ozone in 2000
Lower Newcastle - Miramichi



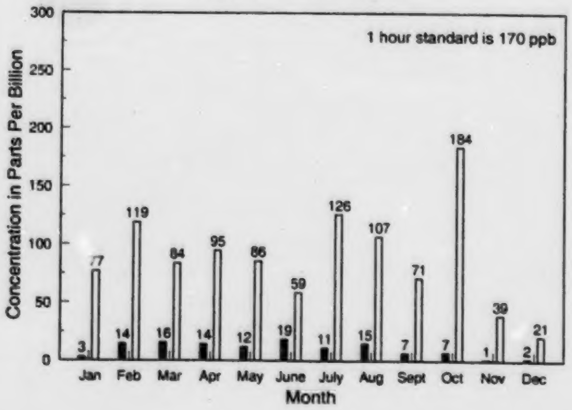
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Champlain Heights - Saint John



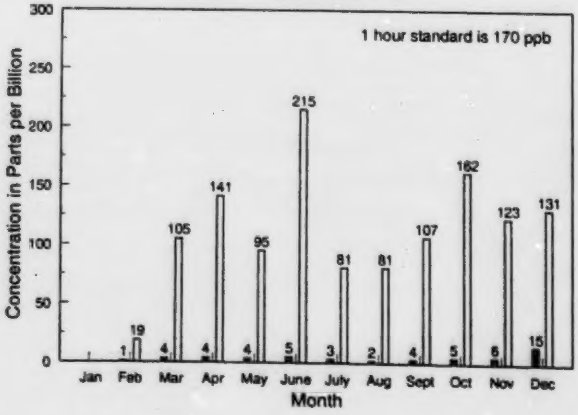
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Customs Building - Saint John



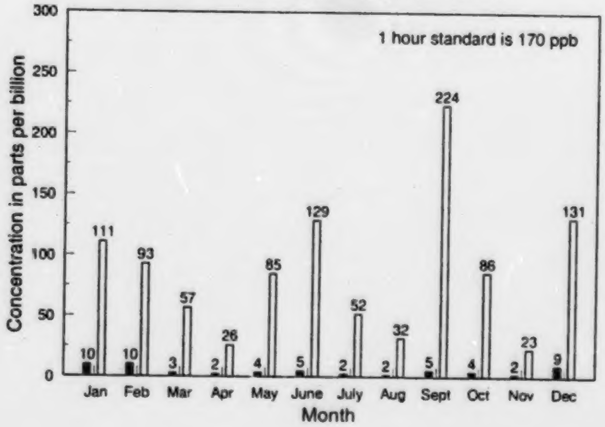
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Forest Hills - Saint John



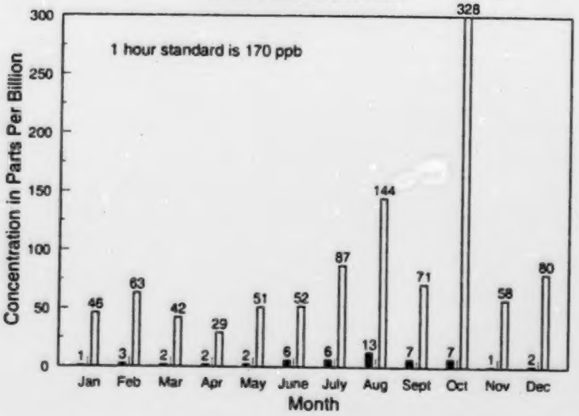
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Forest Products-Saint John



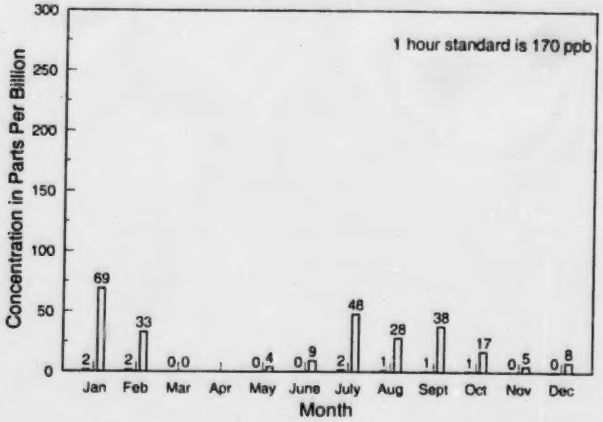
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
West Side Station (Hillcrest) - Saint John



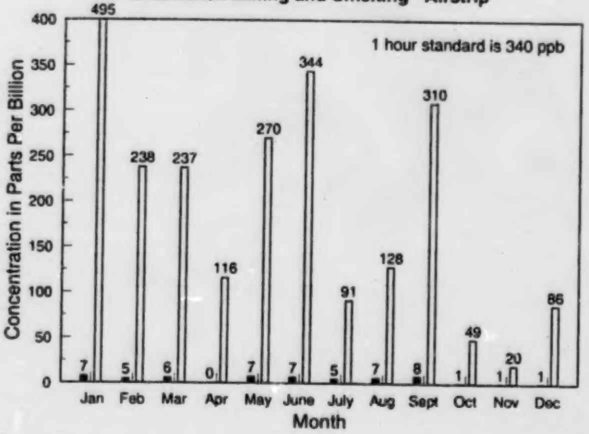
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Silver Falls - Saint John



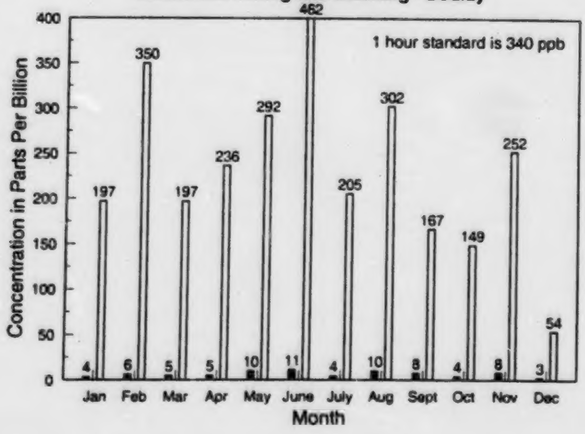
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Three Mile Irving - Saint John



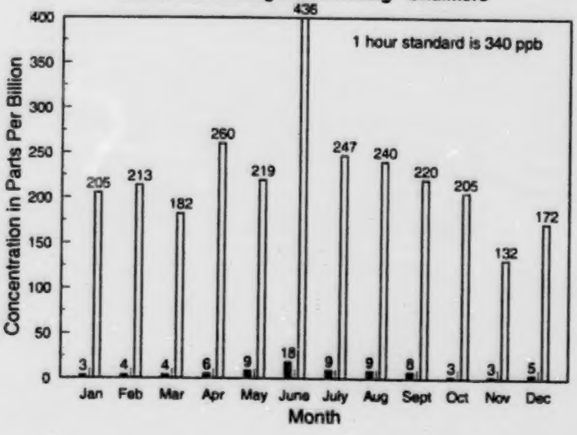
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Brunswick Mining and Smelting - Airstrip



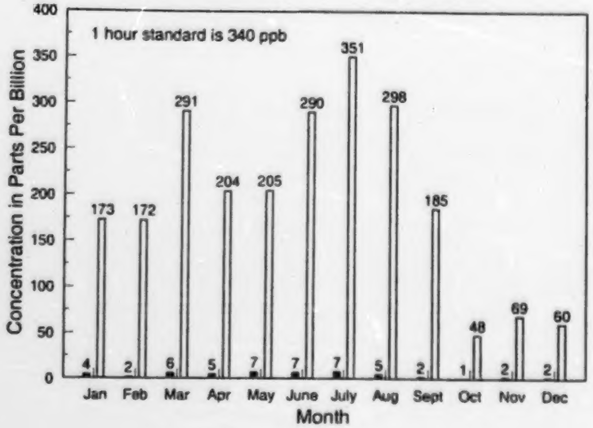
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Brunswick Mining and Smelting - Boulay



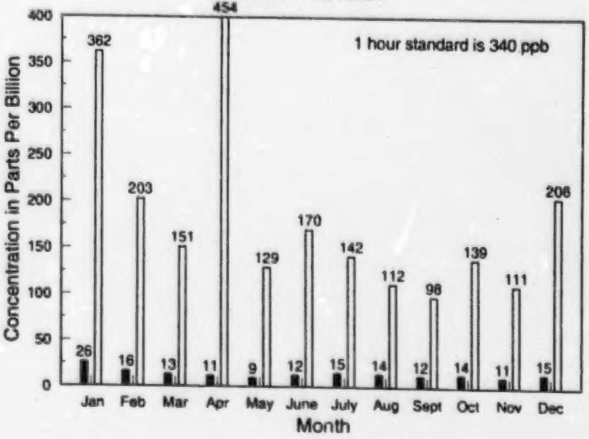
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Brunswick Mining and Smelting - Chalmers



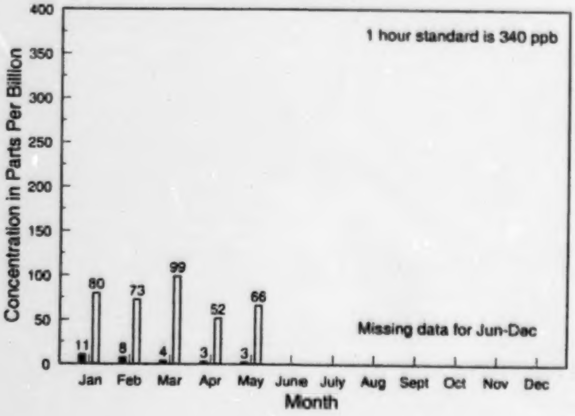
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Brunswick Mining and Smelting - Townsite



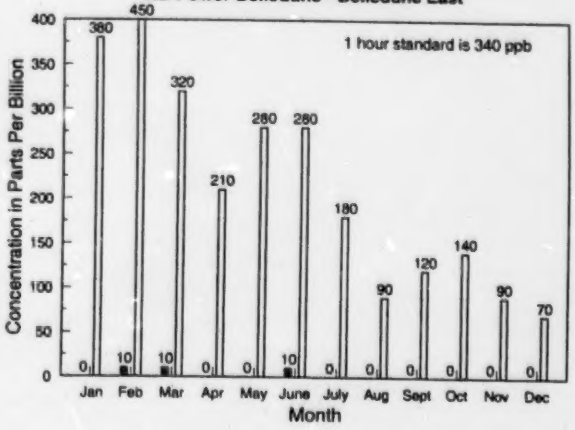
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Fraser - Cormier



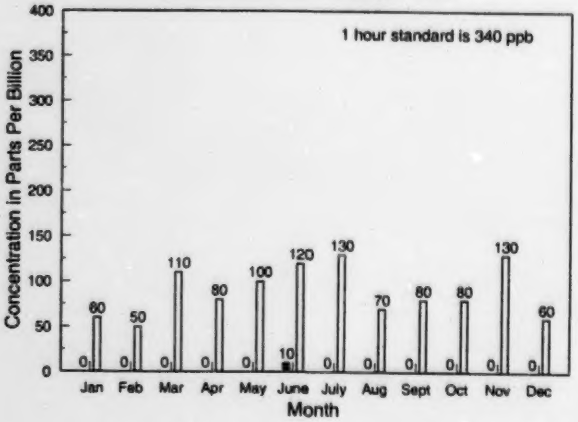
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Fraser - Sacred Heart



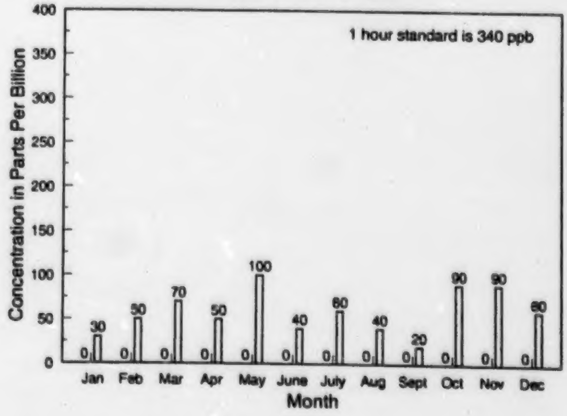
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Belledune - Belledune East

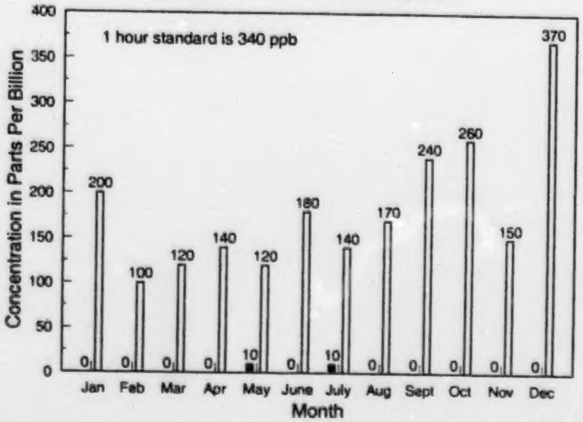


Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Belledune - Jacquet River

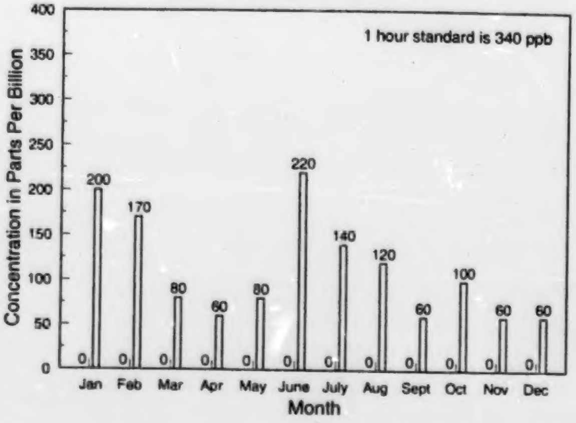


Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Belledune - Madran

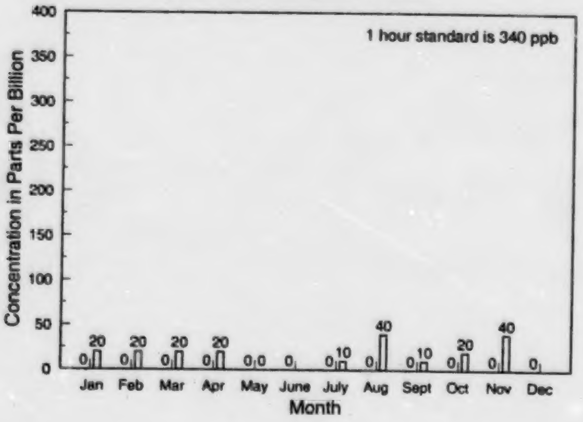




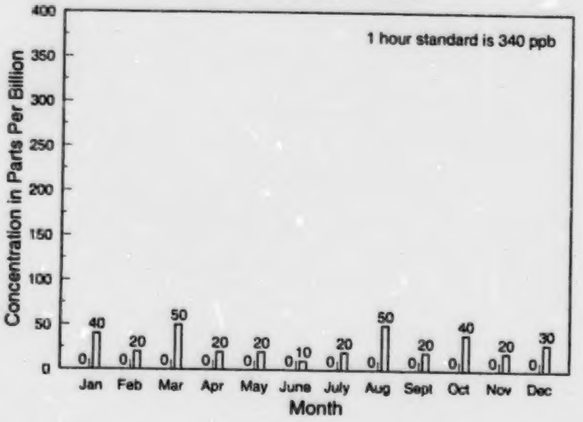
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Belledune - Municipal Hall



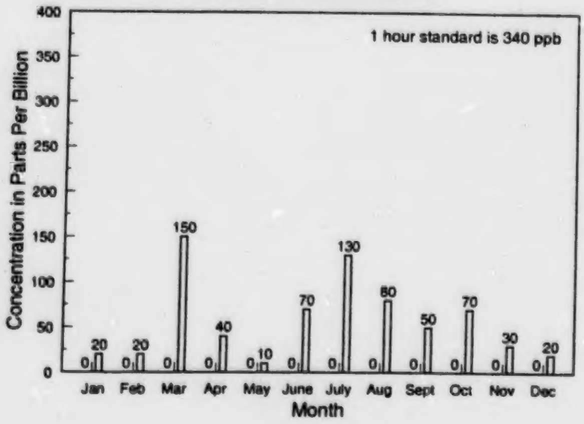
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Belledune - Pointe-Verte



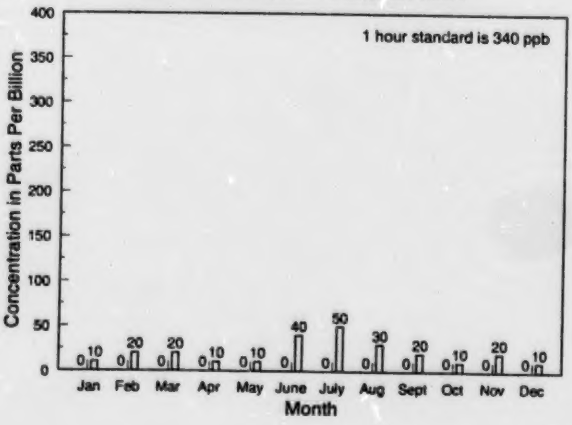
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Carleton



Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Charlo

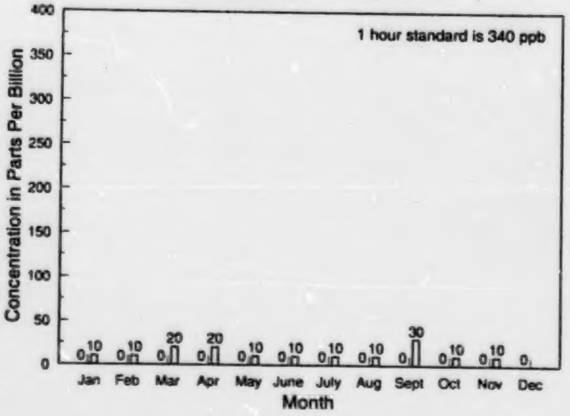


Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Bayview

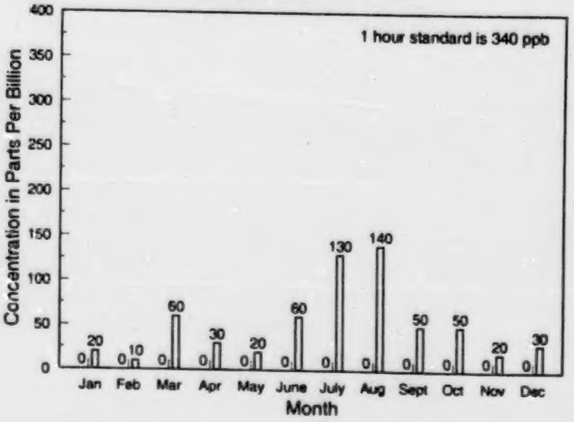


Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Dalhousie Tower

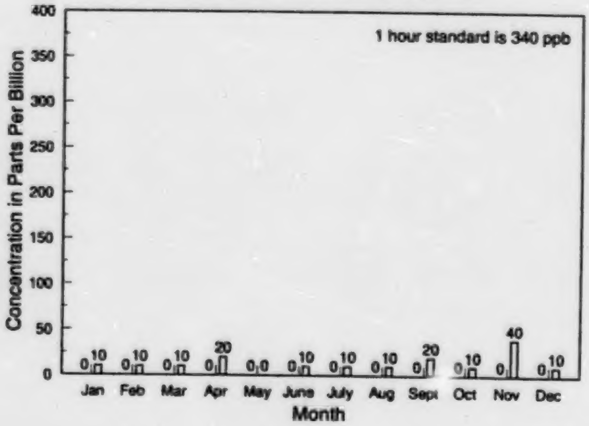
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Miguasha



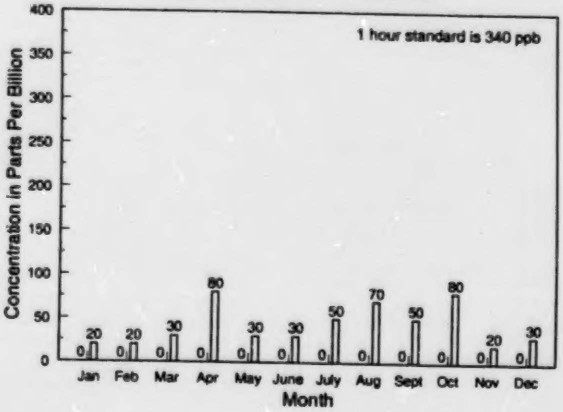
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Mobile



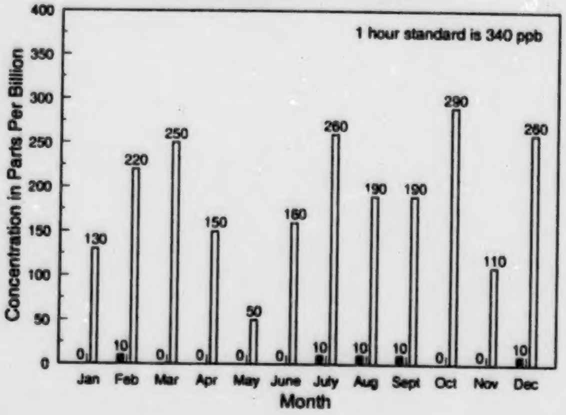
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Pointe-a-la-Garde



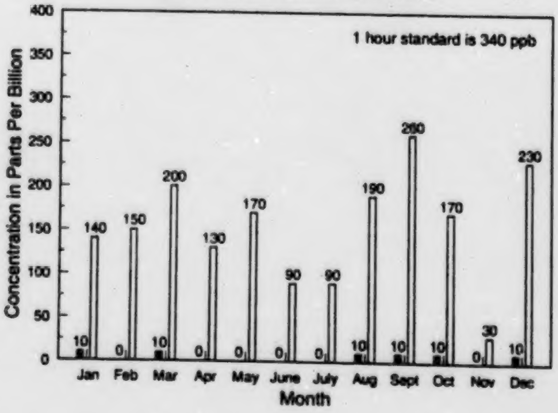
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Dalhousie - Point la Nim



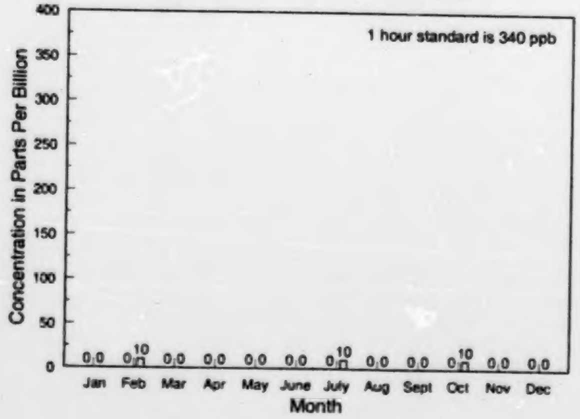
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Grand Lake - Bailey Point



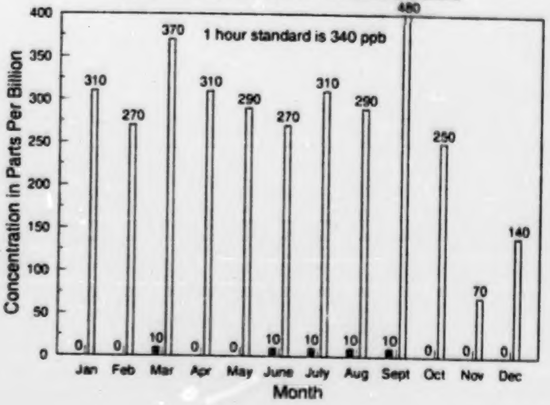
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Grand Lake - Cox Point



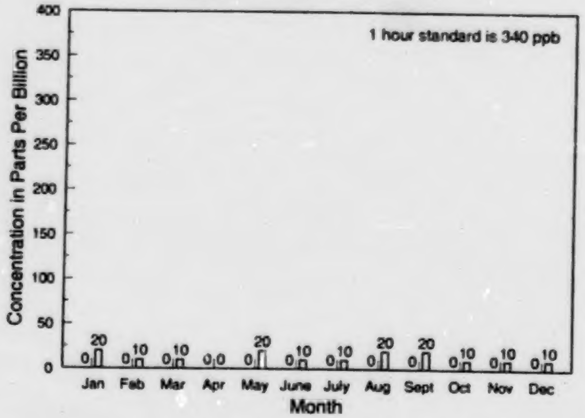
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Grand Lake - Flowers Cove



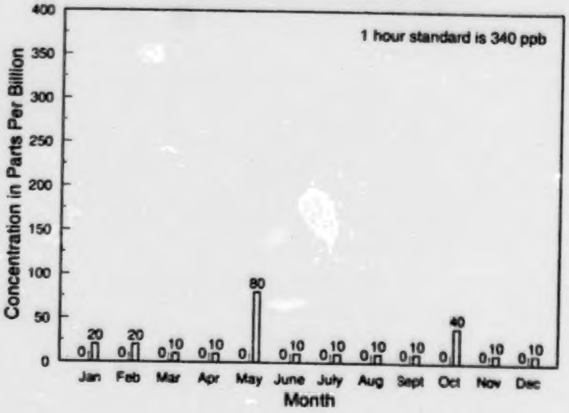
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Grand Lake - Newcastle Centre



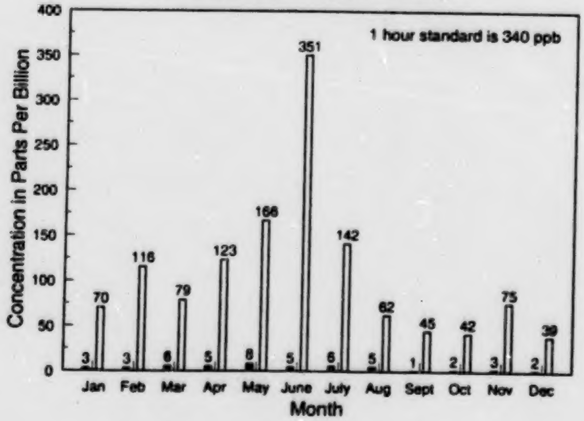
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Millbank - Rockcliff



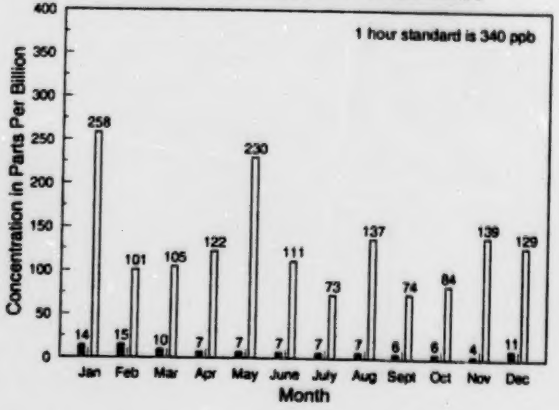
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
NB Power Millbank - Lower Newcastle

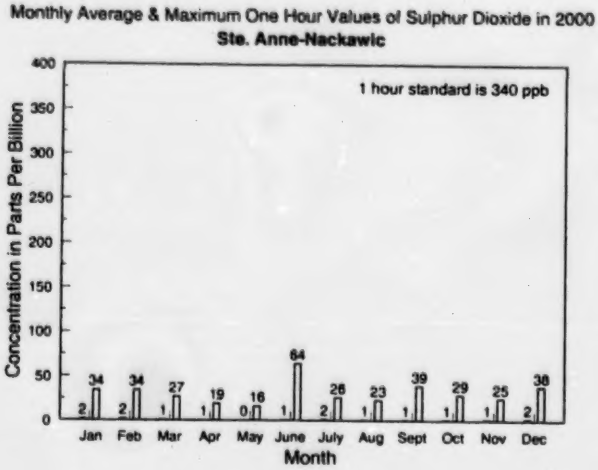


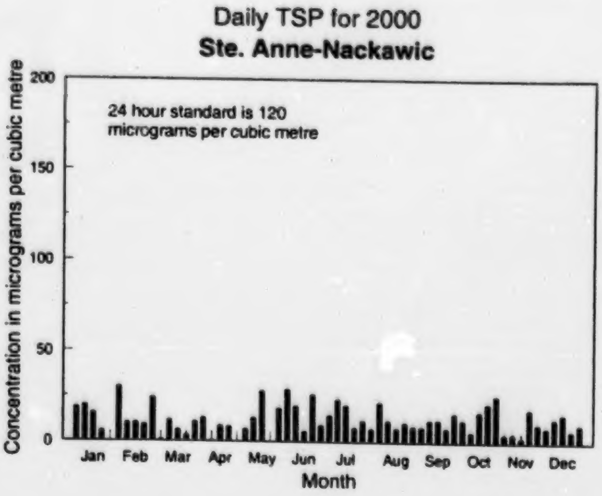
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
AV Cell Atholville - Boom Road (W)

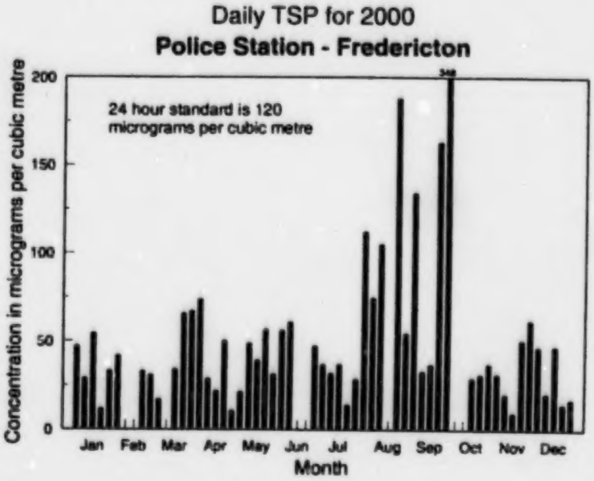


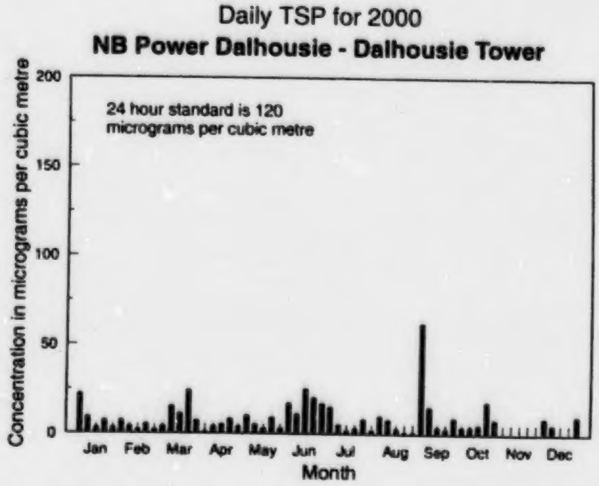
Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
AV Cell Atholville - Dairy Queen/Beauvista (E)

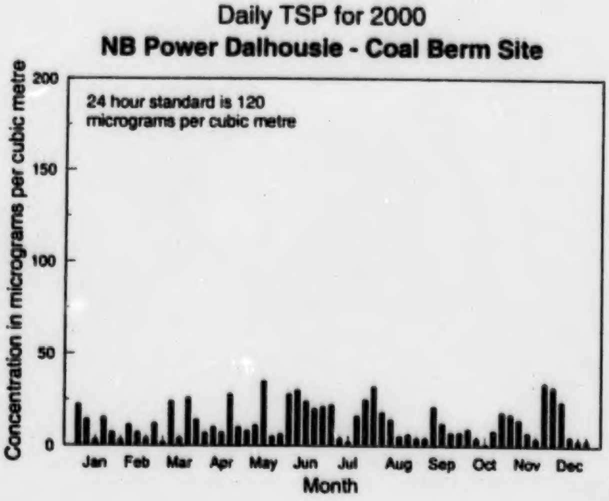


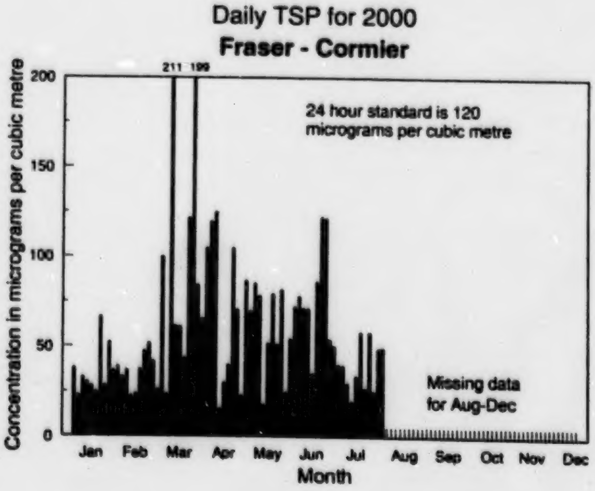

Monthly Average & Maximum One Hour Values of Sulphur Dioxide in 2000
Ste. Anne-Nackawic
1 hour standard is 340 ppb
Concentration in Parts Per Billion
0
50
100
150
200
250
300
350
400
2
34
2
34
1
27
1
19
0
16
1
64
2
26
1
23
1
39
1
29
1
25
2
30
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
Month


Daily TSP for 2000
Ste. Anne-Nackawic
24 hour standard is 120 micrograms per cubic metre
Concentration in micrograms per cubic metre
0
50
100
150
200
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

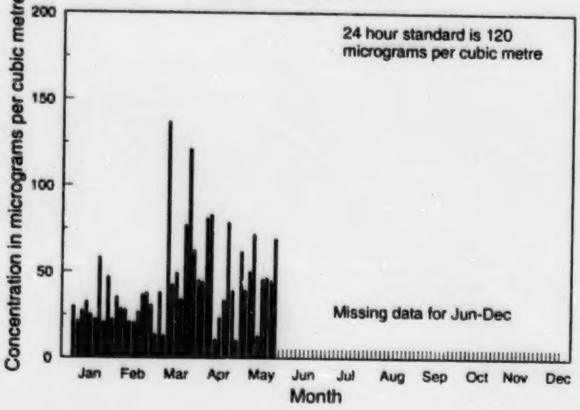

Daily TSP for 2000
Police Station - Fredericton
348
24 hour standard is 120 micrograms per cubic metre
Concentration in micrograms per cubic metre
0
50
100
150
200
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Daily TSP for 2000
NB Power Dalhousie - Dalhousie Tower
24 hour standard is 120 micrograms per cubic metre
Concentration in micrograms per cubic metre
0
50
100
150
200
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

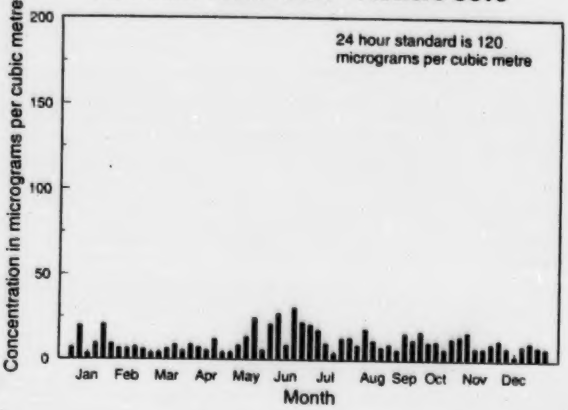

Daily TSP for 2000
NB Power Dalhousie - Coal Berm Site
24 hour standard is 120 micrograms per cubic metre
Concentration in micrograms per cubic metre
0
50
100
150
200
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month


Daily TSP for 2000
Fraser - Cormier
211
199
24 hour standard is 120 micrograms per cubic metre
Missing data for Aug-Dec
Concentration in micrograms per cubic metre
0
50
100
150
200
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

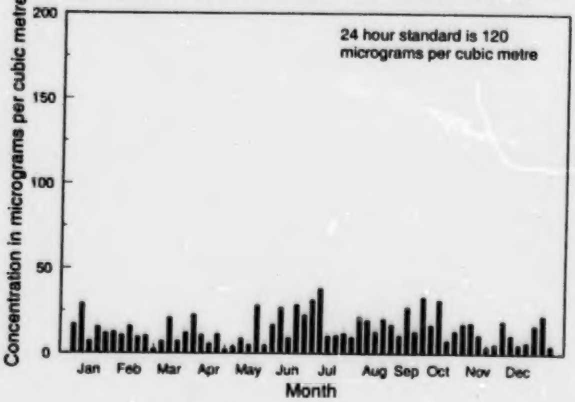
Daily TSP for 2000
Fraser - Sacred Heart



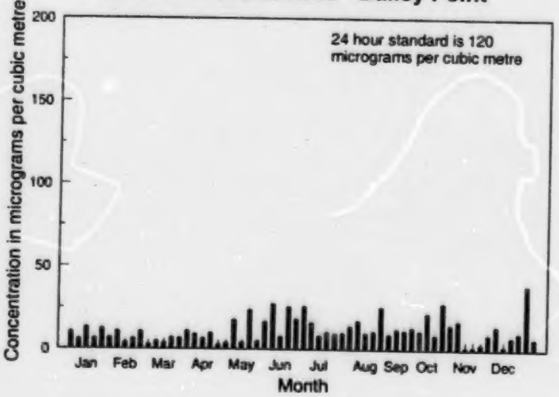
Daily TSP for 2000
NB Power Grand Lake - Flowers Cove



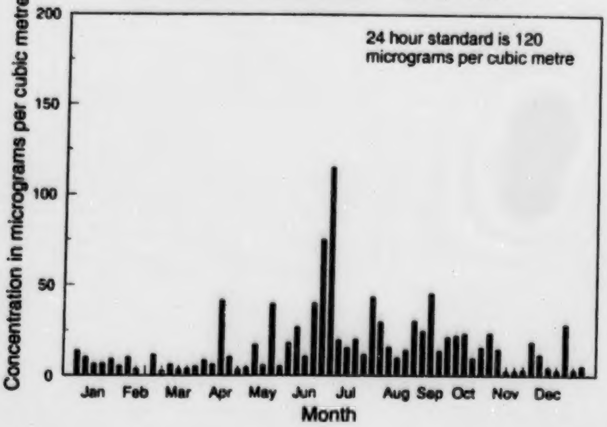
Daily TSP for 2000
NB Power Grand Lake - Newcastle Centre



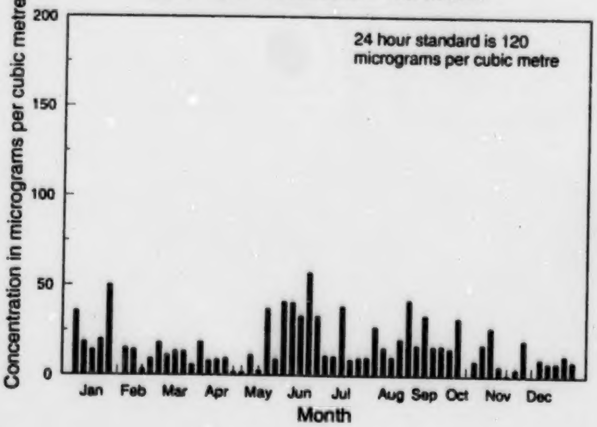
Daily TSP for 2000
NB Power Grand Lake - Bailey Point

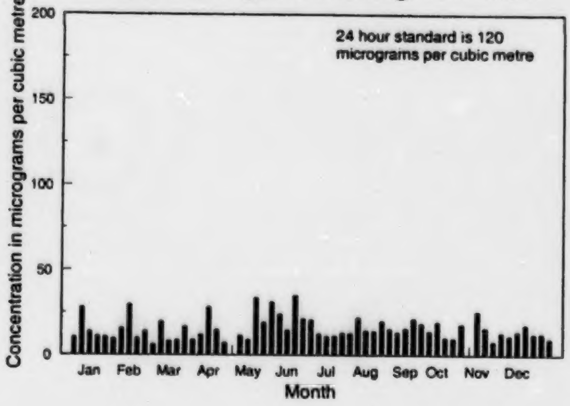


Daily TSP for 2000
NB Power Grand Lake - Cox Point



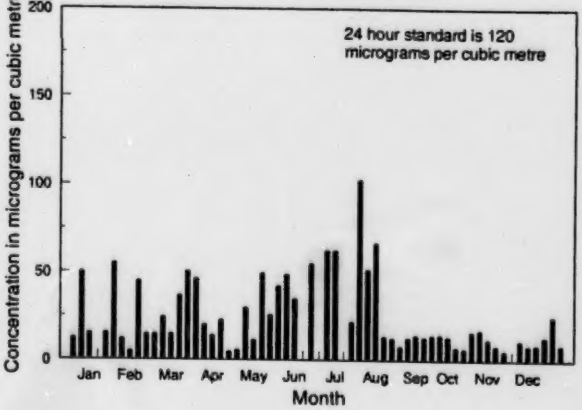
Daily TSP for 2000
NB Power Millbank - Rockcliff





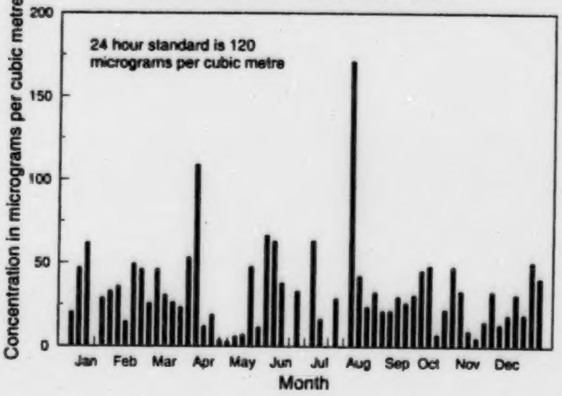
Daily TSP for 2000

Brunswick Mining and Smelting - Chalmers



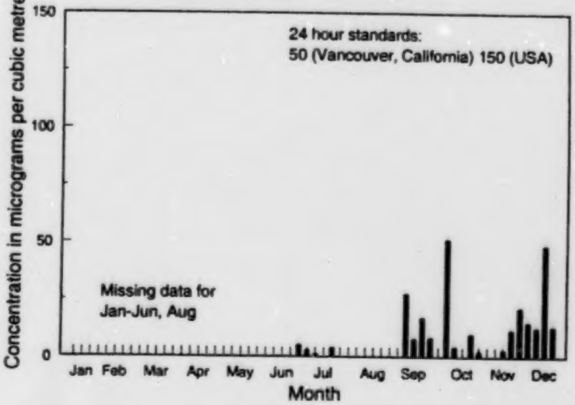
Daily TSP for 2000

Weyerhaeuser - Mirview



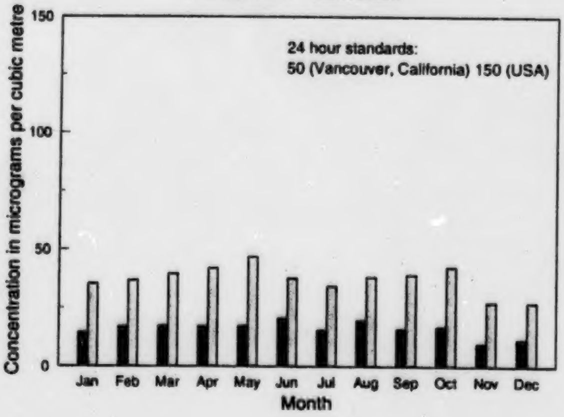
Daily TSP for 2000

Weyerhaeuser - Morrison Cove



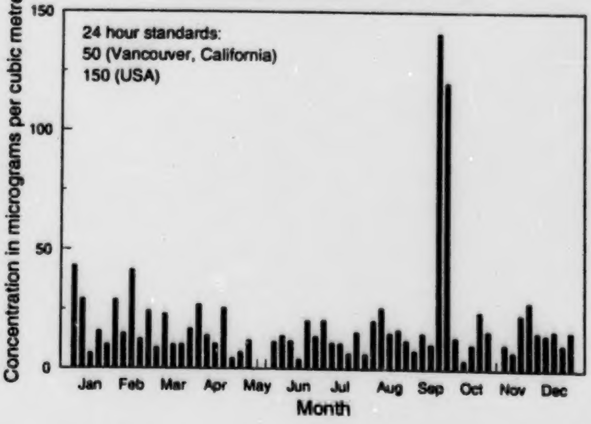
Daily PM10 for 2000

Forest Hills - Saint John



Monthly Average & Maximum 24-hour values of PM10 (TEOM) for 2000

Forest Hills - Saint John

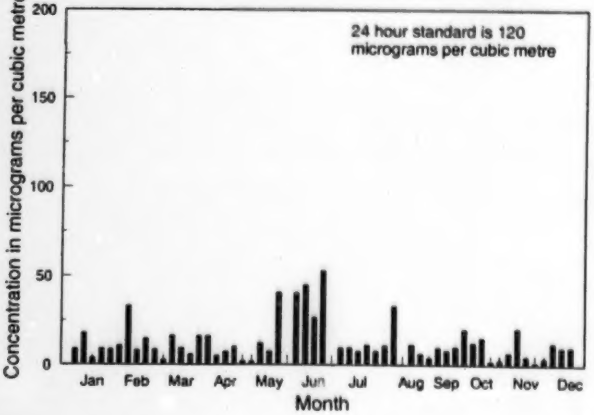


Daily PM10 for 2000

Provincial Building - Saint John

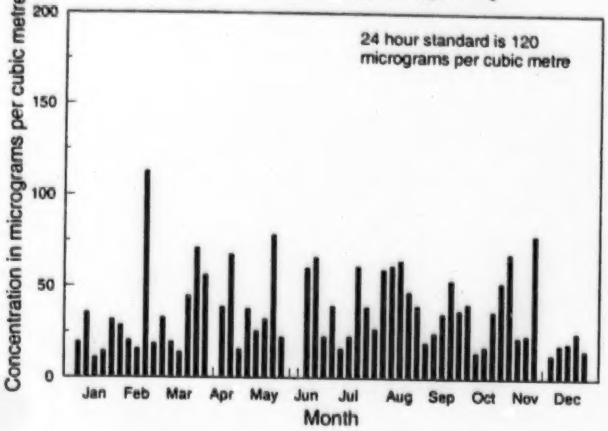
Daily TSP for 2000

NB Power Millbank - Lower Newcastle



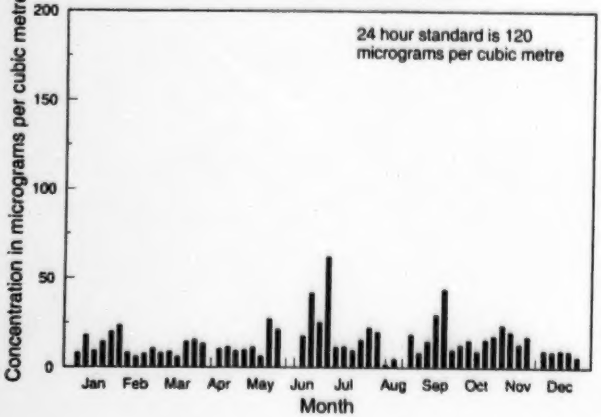
Daily TSP for 2000

REPAP - King George Highway



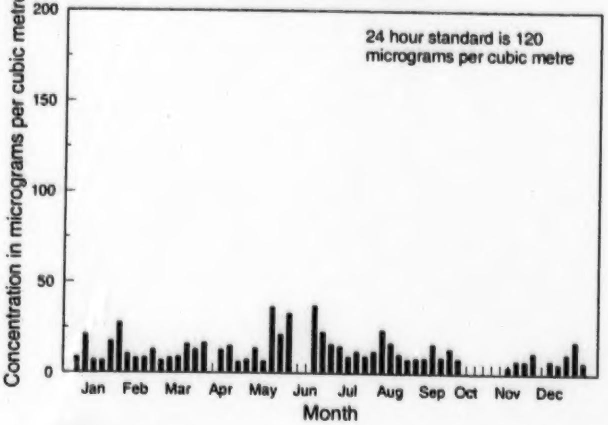
Daily TSP for 2000

REPAP - Groundwood Mill



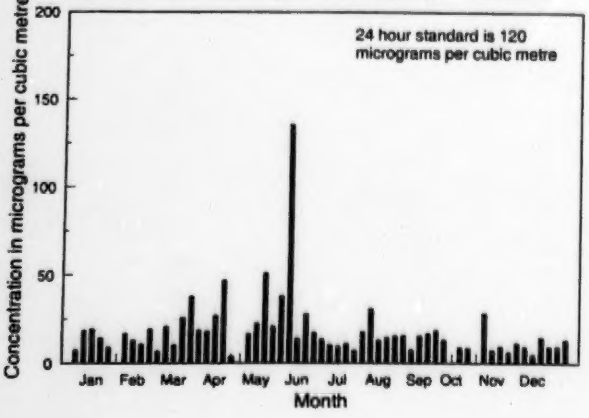
Daily TSP for 2000

REPAP - South Esk



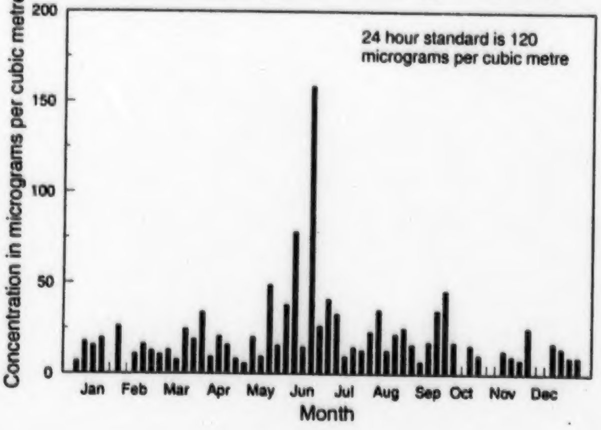
Daily TSP for 2000

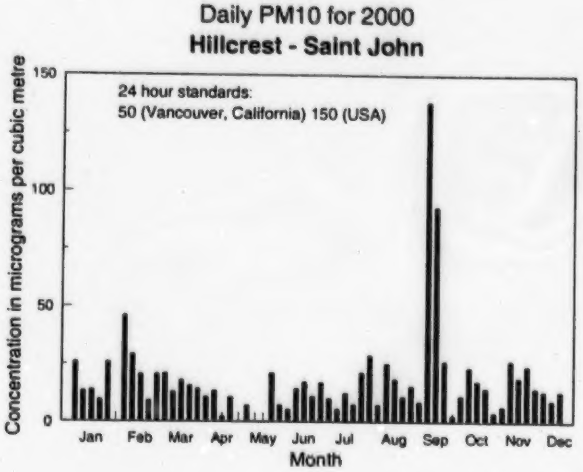
Brunswick Mining and Smelting - Airfield

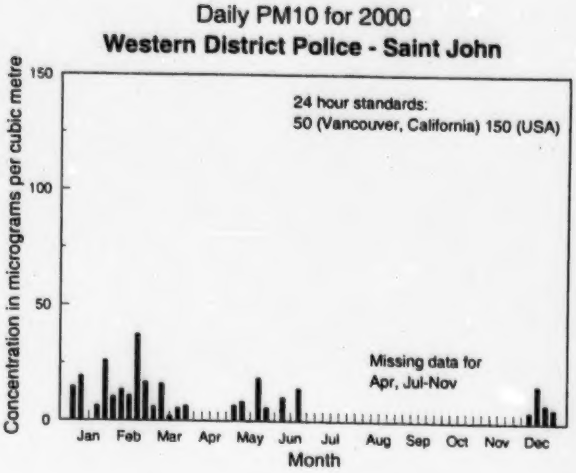


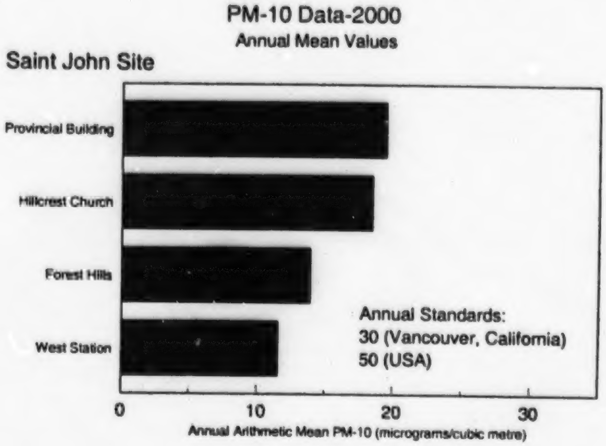
Daily TSP for 2000

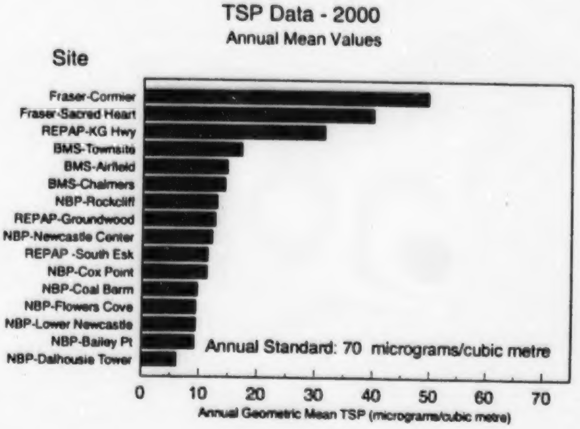
Brunswick Mining and Smelting - Townsite

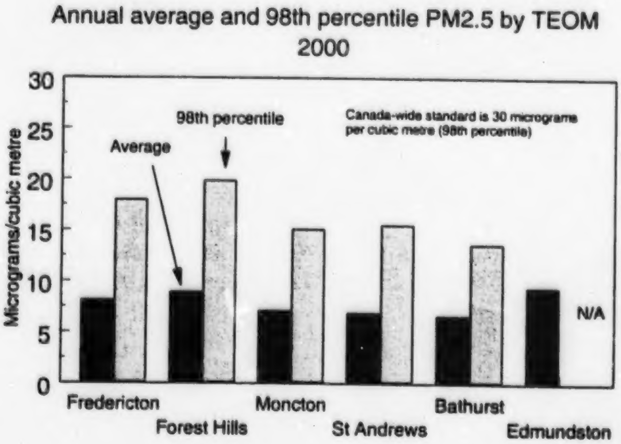



Daily PM10 for 2000
Hillcrest - Saint John


Daily PM10 for 2000
Western District Police - Saint John

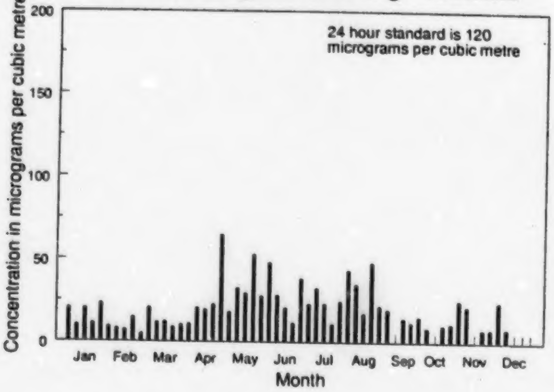

PM-10 Data-2000
Annual Mean Values


TSP Data - 2000
Annual Mean Values


Annual average and 98th percentile PM2.5 by TEOM
2000

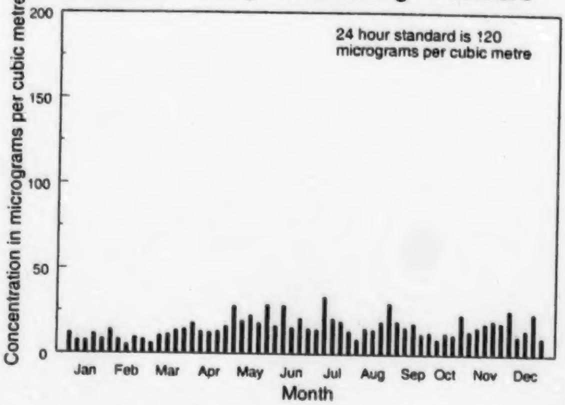
Daily TSP for 1999

Brunswick Mining and Smelting - Townsite


24 hour standard is 120 micrograms per cubic metre

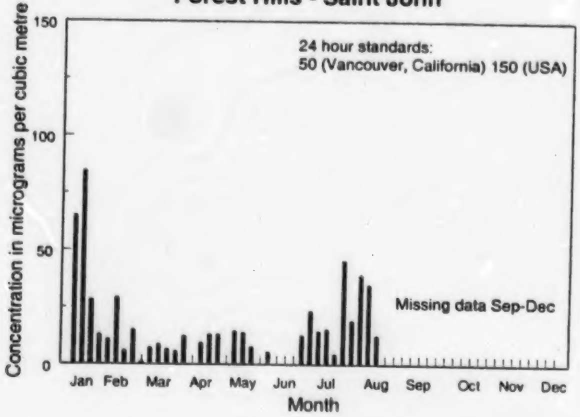
Daily TSP for 1999

Brunswick Mining and Smelting - Chalmers


24 hour standard is 120 micrograms per cubic metre

Daily PM10 for 1999

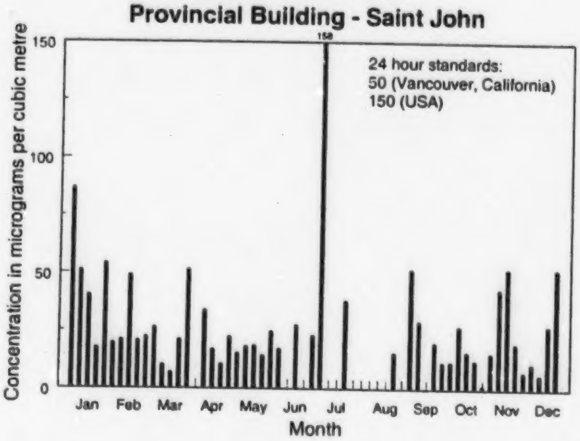
Forest Hills - Saint John


24 hour standards:
50 (Vancouver, California) 150 (USA)

Missing data Sep-Dec

Daily PM10 for 1999

Provincial Building - Saint John


24 hour standards:
50 (Vancouver, California)
150 (USA)

REFERENCES

Aldighieri, A.M. (Ed.) 1998. Canadian Almanac and Directory. Micromedia, Toronto.

Bates, D.V., 1980. The health effects of air pollution. J. Respir. Disease 1: 29-37.

Blomberg, A., 1998. Respiratory effects of atmospheric pollutants: from science to the clinic. Presentation at the ERS/98 Symposium, Geneva, Switzerland, reproduced on the ENVENG internet mailing list, September 27, 1998.

CARB, California Air Resources Board, 1992. Initial Statement of reasons for rulemaking, identification of 1,3 butadiene. http://www.arb.ca.gov/toxics/summary/13butadi.htm

CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1987a. Review of national ambient air quality objectives for nitrogen dioxide; desirable and acceptable levels. Environment Canada, Conservation and Protection, Ottawa, 24 pp.

CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1987b. Review of national ambient air quality objectives for sulphur dioxide; desirable and acceptable levels. Environment Canada, Conservation and Protection, Ottawa, 31 pp.

CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1994. National ambient air quality objectives for carbon monoxide. Minister of Public Works and Government Services Canada, 161 pp.

CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1998. National ambient air quality objectives for particulate matter. Minister of Public Works and Government Services Canada.

CEPA/FPAC Working Group on Air Quality Objectives and Guidelines, 1998. National ambient air quality objectives for carbon monoxide: Desirable, acceptable and tolerable levels. Minister of Public Works and Government Services Canada, Ottawa, 161 pp.

Commission for Environmental Cooperation, 1997. Long-range transport of ground-level ozone and its precursors: Assessment of methods to quantify transboundary transport within the northeastern United States and eastern Canada. Commission for Environmental Cooperation, Montréal, Québec, 108 pp.

Dann, T. F. 1994. PM10 and $PM_{2.5}$ Concentrations at Canadian urban sites: 1984-1993. Unpublished report of the Technology Development Directorate, Environment Canada, Ottawa.

Dann, T.F. 1998. Ambient air measurements of polycyclic aromatic hydrocarbons (PAH), polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans in Canada (1987-1997). Unpublished report of the Technology Development Directorate, Environment Canada, Ottawa.

Delauriers, M., 1996. Canadian emissions inventory of criteria air contaminants (1990). Environment Canada, Ottawa; Environmental Protection Series, Report EPS 5/AP/7E.

Environment Canada, 1984. Hydrogen sulphide: Environmental and technical information for problem spills. Environmental Protection Service, Ottawa, 112 pp.

Environment Canada, 1985. Sulphur dioxide, Environmental and technical information for problem spills. Environmental Protection Service, Ottawa, 111 pp.

Environment Canada, 1998. National Pollutant Release Inventory, Canadian Environmental Protection Act, Summary Report, 1996. 226 pp.

EPAQS, 1994. Expert Panel on Air Quality Standards, Benzene, 1994. Department of The Environment, London.

HMSO, 2000. Environmental Protection, England. The Air Quality (England) Regulations 2000. 2000 No. 928. Her Majesty's Stationery Office, London. ISBN 0-11-099043-9. Also see: http://www.environment.detr.gov.uk/airq/airqual/index.htm.

Jaques, A., F. Neizert and P. Boileau, 1997. Trends in Canada's greenhouse gas emissions, 1990-1995. Environment Canada, Air Pollution Prevention Directorate, Ottawa.

Lalonde, Girouard, Letendre et Associés, 1993. PAH emissions into the Canadian Environment -1990. Report prepared for Environment Canada, Québec region.

Masters, G.M., 1997. Introduction to environmental engineering and science, 2nd Edition. Prentice-Hall, Upper Saddle River, NJ, 651 pp.

Multistakeholder NOx/VOC Science Program, 1997a. Canadian NOx/VOC Science Assessment: Ground level ozone and its precursors, 1980-1993. Report of the Data Analysis Working Group, Dann, T. and P. Summers, Eds. 295 pp.

Multistakeholder NOx/VOC Science Program, 1997b. Canadian NOx/VOC Science Assessment: Modelling of ground-level ozone in the Windsor-Québec City corridor and in the southern Atlantic region. Report of the WQC Corridor and Southern Atlantic Region Modelling Working Group. Venkatesh, S. and B. Beattie, Eds. 265 pp.

Multistakeholder NOx/VOC Science Program, 1997c. Canadian NOx/VOC Science Assessment: Report of the Health Objective Working Group, Wilby, K, G. Wood and D. Galarneau, Eds., 109 pp.

NADP, 2000. National Atmospheric Deposition Program. Web site: http://nadp.sws.uiuc.edu/

NEGECP, 1998. New England Governors and Eastern Canadian Premiers Mercury Action Plan. Conference of New England Governors and Eastern Canadian Premiers, Halifax, NS.

NESCAUM, 1998. Northeast States and Eastern Canadian Provinces Mercury Study: A framework for action. Editor Marika Tatsutani. NESCAUM, Boston, Mass.

OECD, 1995. Control of Hazardous Air Pollutants in OECD Countries, OECD, Paris.

Ritchie, I., 1991. Introduction to indoor air quality: a reference manual. Washington, D.C. US Environmental Protection Agency, EPA/400-3-91-003.

Statistics Canada, 1999. Information on transport statistics taken from website: http://www.statcan.ca/english/Pgdb/Economy/Communications/trade14.htm.

Stewart, R.L., 1975. The effect of carbon monoxide on humans. Ann Rev. Pharmacol. 15: 409-423.

Tordon, R., P. George, S.T. Beauchamp and K. Keddy, 1994. Source sector analysis of ozone exceedance trajectories in the Maritime region (1980-1993). Environment Canada, Atmospheric Environment Service, Report MAES 2-94, 60 pp.

Transport Canada, 1999. Information on transport statistics taken from web site: http://www.tc.gc.ca/tfacts/anre1998/TC9806DE.HTM.

US EPA, 1980. Significant harm levels for carbon monoxide. Research Triangle Park, NC, Office of Air Quality Planning and Standards.

WHO, 1987. Air Quality Guidelines for Europe, World Health Organisation, WHO Regional Publications, European Series No. 23, Copenhagen.

WHO, 1994. Chloroform. Environmental Health Criteria 163, World Health Organisation, Geneva.

WHO, 1996. Ethylbenzene. Environmental Health Criteria 186, World Health Organisation, Geneva.

WHO, 1997. Xylenes. Environmental Health Criteria 190, World Health Organisation, Geneva.

Wilson, R. and J. D. Spengler (Eds.), 1996. Particles in our air: concentrations and health effects. Harvard University Press, 259 pp.